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TMO

INSTRUCTION BOOK

TYPE TMO INTERMEDIATE-FREQUENCY AIRPORT TRANSMITTER

FREQUENCY RANGE 200-400 KC.
SERIAL NUMBERS 1-332

MANUFACTURED FOR

U. S. DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

UNDER

CONTRACTS	ORDER NOS.	DATED	SERIAL NOS.
CCA-15763	42-7414	February 13, 1942	1 to 168
CCA-19432	43-3906	October 27, 1942	169 to 280
CCA-19432	44-2447	October 25, 1943	281 to 332

BY

AIR ASSOCIATES, INC.
LOS ANGELES, CALIFORNIA

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WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OBSERVE SAFETY PRECAUTIONS AT ALL TIMES.

Withdrawal of any unit from the cabinet disconnects all voltages from that unit. Removal of the back cover to the equipment **does not remove voltage from any circuit.**

Before making adjustments from the rear with the back shield cover removed, turn FILAMENT switch to OFF, and open the power supply switch for that transmitter at the main distribution panel.

Before working on a withdrawn power supply or modulator chassis, discharge high-voltage capacitors within that chassis.

Do not withdraw all units from the cabinet simultaneously unless the cabinet is bolted to the floor.

GUARANTEE

All items of equipment and material used in the type TMO transmitter are guaranteed against material defects, workmanship or manufacture for a period of one year from date of installation and commissioning by the Government except, however, Air Associates, Inc. does not guarantee the items of equipment and materials for a term longer than two years from the date of inspection and acceptance by the Government.

Under the terms of this guarantee all items furnished which fail in normal operation will be replaced f.o.b. point of installation without cost to the Government except for installation. Immediately upon receipt of notification that an item has failed within the normal guarantee period the Company will furnish a replacement without awaiting return of the damaged part. Replacement items will be shipped from the Company's plant or its supplier's plant within twenty (20) days after notification of the failure is received. If, due to wartime conditions, the Company can not replace the defective part within twenty (20) days, replacement will be made as soon as possible. The Company will pay transportation charges on any defective part it desires returned to its plant. If upon examination of the defective item, the Company can show to the satisfaction of the Government that the failure is not due to defects in material, workmanship or manufacture, the Company will bill the Government for the cost of replacement including transportation. In the event of failure of twenty per cent (20%) or more of like parts on this contract, it will be considered conclusive proof that the particular part in question is not suited for the purpose intended and the Company will replace that part in all equipment without cost to the Government except for installation.

When a failure is reported by the Government under the terms of this Guarantee, the Company asks that the Government submit a detailed report as to the nature of the failure. This report should include all items listed under REPLACEMENT OF PARTS.

AIR ASSOCIATES, INC.
Los Angeles, Calif.

REPLACEMENT OF PARTS

In case a replacement is required under terms of the guarantee, a report is requested by the Company which should include the following information:

1) Serial number of transmitter
2) Date placed in service
3) Number of hours in service, if available
4) Part and item number
5) Nature of failure and its cause

When ordering replacement parts, not under terms of the guarantee, the following information should be given:

1) Serial number of equipment
2) Quantity required
3) Part number (obtain from Parts-List, Section 5, or schematic diagram Fig. 28.)

SUMMARY OF TRANSMITTER CHARACTERISTICS

CARRIER CAPABILITIES

FREQUENCY RANGE 200-400 KC.

POWER OUTPUT-UNMODULATED into 10-ohm 500-mmfd. Dummy Antenna.

200 KC.	21 Watts
283 KC.	26 Watts
400 KC.	31 Watts

POWER SUPPLY REQUIREMENTS (for full power output)

FREQUENCY (Single Phase)	60 cps
VOLTAGE	105-120 Volts
CURRENT (120 Volts), FULL POWER	4.0 Amperes
POWER INPUT (120 Volts) FULL POWER	410 Watts
POWER INPUT (120 Volts) STAND-BY	190 Watts
INPUT POWER FACTOR (120 Volts) FULL POWER	85%

WEIGHTS AND DIMENSIONS

	Net Weight	Crated Weight
CABINET	150 lbs.	205 lbs.
POWER-SUPPLY UNIT	103 lbs.	135 lbs.
MODULATOR UNIT	74 lbs.	99 lbs.
RADIO-FREQUENCY UNIT	30 lbs.	51 lbs.
LOAD COIL UNIT	19 lbs.	40 lbs.
ACCESSORIES	12 lbs.	27 lbs.
	Total Net Weight	Total Crated Weight
	388 lbs.	557 lbs.

DIMENSIONS—MAXIMUM OUTSIDE

HEIGHT	42-¾ inches
WIDTH	20-½ inches
DEPTH	18-¾ inches

VACUUM TUBE COMPLEMENT

Item	Type	Quantity	Circuit Function
V1, V2	866A	2	High-Voltage Rectifiers
V3	5Z3	1	Low-Voltage Rectifier
V4	6SJ7	1	Audio Amplifier
V5	6V6G	1	Audio Driver
V6, V7	807	2	Modulators
V8	6V6G	1	Crystal Oscillator
V9	6V6G	1	Radio-Frequency Buffer
V10, V11	807	2	Power Amplifiers

TABLE OF CONTENTS

Page No.

INTRODUCTION
- Title Page i
- Warning iii
- Guarantee Clause iv
- Replacement of Parts v
- Summary of Transmitter Characteristics vi
- Vacuum Tube Complement vi
- List of Illustrations x
- List of Charts and Drawings x

1. DESCRIPTION OF UNIT 1
  - 1.1 General 1
    - 1.11 Purpose 1
    - 1.12 Summary of Electrical Description 1
    - 1.13 Housing and Chassis Components 1
      - 1.131 Power-Supply Unit 1
      - 1.132 Modulator Unit 1
      - 1.133 Radio-Frequency Unit 2
      - 1.134 Antenna Load Coil Unit 2
      - 1.135 Fusing 3

  - 1.2 MECHANICAL CONSTRUCTION 3
    - 1.21 General 3
    - 1.22 Removable Chassis 3
    - 1.23 Roller Track Mechanism 4
    - 1.24 Chassis Removal 4
    - 1.25 Inter-Unit Wiring and Patchcord Connectors 4
    - 1.26 Ventilating System 5

  - 1.3 ELECTRICAL THEORY OF OPERATION 5
    - 1.31 Crystal Oscillator 5
    - 1.32 Buffer Amplifier 5
    - 1.33 Power Amplifier 6
    - 1.34 Output Circuit 6
      - 1.341 Local Antenna 6
      - 1.342 Remote Antenna 6
    - 1.35 Speech and Input Circuits 7
      - 1.351 Tone Oscillator Circuit 7
    - 1.36 Modulators 8

TABLE OF CONTENTS

Page No.

1.37 Power 8
  1.371 Low-Voltage Supply 8
  1.372 Bias Supply 8
  1.373 High-Voltage Supply 8
1.38 Control Circuits 9
1.4 MODIFICATIONS 10

2. INSTALLATION 12
2.1 GENERAL 12
2.2 UNPACKING 12
2.3 ASSEMBLY 12
2.4 WIRING DESIGNATION 13
2.5 FUSE AND TRANSFORMER CHECK 14
2.6 REPACKING 15

3. TRANSMITTER ADJUSTMENT PROCEDURE 16
3.1 PRELIMINARY 16
  3.12 **PRECAUTIONS** 16
3.2 CRYSTAL OSCILLATOR STAGE 16
3.3 BUFFER AMPLIFIER 16
3.4 POWER AMPLIFIER 16
3.5 ANTENNA LOAD COIL 17
3.6 REMOTE ANTENNA INSTALLATION 17
  3.61 Load Coil Unit Changes 17
    3.611 Wiring Changes 17
    3.612 Transmission Line Series Capacitors 18
  3.62 Load Coil Unit Housing 18
  3.63 Adjustment of Remote Antenna 19
    3.631 General 19
    3.632 Tuning Remote Antenna to Resonance 19
    3.633 Matching Section Adjustment for Proper Line Termination 20
    3.634 Adjustment for Proper PA Loading 20
    3.635 Low-Power Operation 20
3.7 AUDIO ADJUSTMENT 21
3.8 SUMMARY OF ADJUSTMENT PROCEDURE 21

4. MAINTENANCE 22
  4.01 General 22
  4.02 Maintenance Responsibility 22
  4.03 Inspection Schedules and Servicing Routines 22
  4.04 Scope of Servicing Routines 22

TABLE OF CONTENTS

Page No.

4.1 ROUTINE MAINTENANCE AND INSPECTION 23
  4.12 Daily Inspection 23
  4.13 Weekly Inspection 23
  4.14 "Minor" Servicing of TMO Transmitters 23
  4.15 "Routine" Servicing of TMO Transmitters 25
  4.16 "Major" Servicing of TMO Transmitters 27
  4.17 Blower Motor Overhaul 28
    4.171 General Electric Type KSC 28
    4.172 A. G. Redmond Type R-Model 123 29
4.2 REPAIR 30
  4.21 Possible Troubles and Remedies 30
    4.211 General 30
    4.212 Fuses 30
    4.213 Radio-Frequency Section 30
    4.214 Capacitors and Resistors 31
    4.215 Inductors 32
    4.216 Audio Section 32
    4.217 Relays 32
4.3 TYPICAL OPERATING DATA 33
  4.31 Vacuum Tube Voltages and Currents 33
  4.32 Resistor Voltages and Dissipation 34
  4.33 Mica and Paper Capacitors—Operating Voltages 35
  4.34 Relay Operate and Release Voltages and Currents and Solenoid DC Resistance 35

5. PARTS LIST 36

5.1 CAPACITORS 36
5.2 FUSES 37
5.3 RELAYS AND CONTACTORS 38
5.4 INDUCTORS 38
5.5 INDICATING INSTRUMENTS 38
5.6 RESISTORS 39
5.7 SWITCHES 40
5.8 TRANSFORMERS—POWER 40
5.9 TRANSFORMERS—AUDIO 40
5.10 TUBE SOCKETS 40
5.11 THERMOSTAT 41
5.12 CRYSTAL 41
5.13 INDICATOR LIGHT 41
5.14 CHASSIS CONNECTORS—PLUGS AND SOCKETS 41
5.15 CHASSIS CONNECTORS—PATCH CORDS 42
5.16 MISCELLANEOUS 43
5.17 CONTACTOR AND RELAY PARTS LIST 44
5.18 LIST OF MANUFACTURERS 46

LIST OF ILLUSTRATIONS

Fig. No.	Title	Page No.
1.	Type TMO Transmitter—Front View	47
2.	Type TMO Transmitter—Rear View—Cover Removed	48
3.	Type TMO Transmitter—Left Side View—Units Withdrawn	49
4.	Type TMO Transmitter—Right Side View—Units Withdrawn	50
5.	TMO Load Coil Unit—Front View	51
6.	TMO Radio-Frequency Unit—Front View	51
7.	TMO Modulator Unit—Front View	52
8.	TMO Power-Supply Unit—Front View	52
9.	TMO Load Coil Unit—Top View	53
10.	TMO Load Coil Unit—Bottom View	53
11.	TMO Radio-Frequency Unit—Top View	54
12.	TMO Radio-Frequency Unit—Bottom View	54
13.	TMO Modulator Unit—Top View	55
14.	TMO Modulator Unit—Bottom View	55
15.	TMO Power-Supply Unit—Top View	56
16.	TMO Power-Supply Unit—Bottom View	56
17.	Incoming Wiring Terminal Block—Unit A	57
18.	Plate and Filament Contactors K2 and K3—Top and Side View	57
19.	Primary Relay K1 and Tone Relay K4	58
20.	Antenna Contactor K5	58
21.	TMO Load Coil Unit in Remote Housing	59
22.	Blower Motor, A. G. Redmond Co., Type R., Model 123	60

LIST OF CHARTS AND DRAWINGS

Fig. No.		Page No.
23	OSC. PLATE Dial Calibration	61
24A	Radio-Frequency Transformer Coupling turns 200 to 283 KC.	63
24B	Radio-Frequency Transformer Coupling turns 283 to 400 KC.	65
25	PA. PLATE Dial Calibration	67
26	Antenna Load Coil Taps	69
27	Antenna Load Coil Matching Section Turns for 70 Ohm Line Connection at Remote Antenna Installations	71
28	TMO Transmitter—Complete Schematic	73
29	TMO Transmitter—Wiring Schematic	74
30	Schematic Diagram Control Circuit	75
31	Wiring Diagram—Power-Supply Unit	76
32	Wiring Diagram—Modulator Unit	77
33A	Wiring Diagram—Radio-Frequency Unit. S/N below 169	78
33B	Wiring Diagram—Radio-Frequency Unit. S/N above 168	79
34	Wiring Diagram—Antenna Load Coil Unit	80
35	Supplementary Schematic Antenna Load Coil Remote Installation	81
36	Wiring Diagram—Load Coil Housing	82
37	Outline Drawing	83

1. DESCRIPTION OF UNIT

1.1 GENERAL

1.11 PURPOSE

The type TMO equipment was designed in conformance with Specification CAA-509 to function primarily as an Airport Traffic Control Radio Transmitter.

1.12 SUMMARY OF ELECTRICAL DESCRIPTION

The type TMO equipment is an intermediate-frequency radiotelephone transmitter consisting of a crystal-controlled oscillator, 6V6G, which drives a 6V6G buffer amplifier. This buffer amplifier supplies radio-frequency energy to two parallel-connected 807 type tubes which serve as power amplifiers. The frequency range is 200 to 400 kilocycles.

Audio voltage is supplied to the 6SJ7 audio amplifier from a regulated output amplifier, not furnished as part of the TMO equipment. The output of the audio amplifier 6SJ7 is amplified by a 6V6G audio driver stage. This, in turn, supplies audio voltage to the push-pull grids of two 807's, operating class AB2, which function to modulate the plate and screen voltage of the class C power amplifier 807 tubes. Tone modulation with a frequency of 1020 cps is also provided.

Because of the capacitive characteristic of the antenna which is employed with the type TMO equipment, a series antenna load coil is required to resonate the antenna circuit. This antenna load coil allows the TMO Transmitter to operate into antennas with a reactive component ranging from 500 micro-micro-farads capacity at 200 kilocycles to 1000 micro-micro-farads capacity at 400 kilocycles, and with a resistive component of from 5 to 20 ohms.

The equipment will deliver 47.5 watts of carrier power into a 70-ohm resistive load at any frequency in the range. Into an antenna of 10 ohms resistance and 500 micro-micro-farads capacity, the type TMO transmitter will deliver 21 watts at 200 kilocycles, 26 watts at 283 kilocycles, and 31 watts at 400 kilocycles.

1.13 HOUSING AND CHASSIS COMPONENTS

The TMO Transmitter is composed of four units housed in a welded steel cabinet with a removable back cover. These four units are mounted on ball-bearing tracks which permit them to be individually withdrawn from the cabinet for inspection or service. Each unit consists of a chassis and front panel as follows:

1.131 POWER-SUPPLY UNIT

The bottom unit in the cabinet is the Power-Supply Chassis which provides d-c screen and plate voltage to the buffer, modulator, and power amplifier stages. A blower mounted on this chassis draws in air through the dust filter on the front panel. A thermostat switch controlling the blower operation is located adjacent to the 866A rectifier tubes. Plate power and filament contactors are mounted on the upper rear section of the front panel on each side of the blower unit. A primary relay controlling the plate power contactor is situated near the blower thermostat switch. An indicator light connected across the filament primary circuit is mounted in the top center section of the front panel.

The power-supply chassis of the type TMO Transmitter is identical with the corresponding chassis of the type TUI, Ultra-High-Frequency Airport Transmitter. However, if these units are temporarily exchanged, a change in the position of primary connections on the high-voltage plate transformer T2 must be made since the type TUI Transmitter operates with lower plate voltage. In Section 2.5, a tabulation of transformer primary connections is given which should be consulted if type TMO and TUI Power-Supply Chassis are temporarily exchanged.

1.132 MODULATOR UNIT

Directly above the power-supply chassis is the modulator unit containing the audio-frequency amplifier stages and low-voltage power-supply. The grid bias voltage for the modulator and radio-frequency stages, as well as plate and screen voltage for the audio amplifier, audio driver and crystal oscillator is furnished by this power-supply. Filament power for the audio amplifier and modulator tubes is obtained from a transformer located on this chassis. In the modulator control compartment are located the audio attenuator, tone modulation key, plate test key, tune-operate switch and filament on-off switch. A meter connected in the modulator plate circuit is mounted in the center of the front panel above the control compartment.

The Modulator chassis of the type TMO Transmitter is identical with the corresponding chassis of the type TUI Transmitter. However, if these units are temporarily exchanged, two changes must be made; first, a change in the position of secondary connections on the modulation transformer T6 should be made since the type TUI modulator load differs somewhat from that of the type TMO. When a modulator unit is operated with TMO equipment, the full secondary of modulation transformer T6 is used. On the TUI, terminals 4 and 5 are normally employed. If a modulator from a type TUI equipment is to be used with type TMO equipment, the two red high- voltage leads connected to terminal 5 on transformer T6 should be moved to terminal 6. The second change necessary if a TUI modulator is to be used in a type TMO transmitter, is the connection of a jumper across the 5600-ohm section of wire-wound resistor R12. This jumper is provided with both TMO and TUI modulators but is disconnected on the type TUI equipment. Connection of this jumper is necessary when a modulator is employed with TMO equipment to limit the screen voltage applied to the type 807 modulator tubes.

1.133 RADIO-FREQUENCY UNIT

The Radio-Frequency chassis is situated immediately above the modulator and consists of a crystal oscillator, buffer amplifier, and class C power amplifier stage. Filament power for all tubes on this chassis is furnished by a transformer identical with that employed on the modulator unit. In the control compartment are located the oscillator plate tuning control and the power amplifier plate tuning control. A meter connected in the oscillator plate circuit is mounted on the left side of the front panel. A meter connected in the power amplifier plate circuit is located on the right side of the front panel.

1.134 ANTENNA LOAD COIL UNIT

The Antenna Load Coil Chassis containing the load coil, antenna ammeter and the antenna contactor is the top unit in the cabinet. This unit occupies this position when used with a local antenna. In the control compartment of this unit are the tuning control for the antenna load coil and tuning chart which lists the position of all variable controls. The antenna current meter is mounted on the right side of the front panel of this unit.

If the particular installation requires a remote antenna, this chassis must be removed from the cabinet and relocated adjacent to the antenna. A blank panel is installed on the cabinet to cover the space formerly occupied by the load coil unit. A 70-ohm coaxial transmission line is then used to conduct radio-frequency power from the transmitter to the remotely-located antenna load coil unit. This unit is housed in a small cabinet provided with tracks identical with those used in the transmitter cabinet, enabling the load coil unit to be withdrawn for service or adjustment. This housing is a welded steel box provided with a rear bracket for mounting on a vertical surface.

The coaxial transmission line from the transmitter is brought up to a terminal board inside the housing through an opening in the bottom of the housing fitted with a clamp to hold the coaxial line. Two knockout holes are provided on the top near the back and on the back near the top to accommodate the antenna bushing assembly supplied with type TMO equipment. The housing is provided with a removable front cover plate and gasket which mounts with captive screws. With the front cover in place, the load coil chassis is completely protected from exposure to the weather. This housing is 22 inches wide, 11 inches high, and 20 inches deep and is finished with an aluminum paint to minimize heat absorption from the sun. When the load coil chassis is removed from the cabinet and housed remotely, a series capacitor assembly C35 and C36 is plugged in between J8 and J10 in the upper section of the TMO Cabinet.

When necessary, this capacitor assembly, remote housing, and the blank front panel for the upper section of the TMO cabinet may be secured from Central Depot, Fort Worth, Texas.

1.135 FUSING

On the Power-supply unit, fuses for the rectifier filament transformer, plate transformer and blower are mounted in extractor type holders located near the left front corner of the chassis. Line fuses mounted in clips are located at the rear of the power supply chassis. On the modulator chassis, fuses for the low-voltage plate transformer and filament transformer are mounted in extractor type holders located toward the rear of this chassis adjacent to the 5Z3 rectifier tube. A fuse in the modulator plate and screen circuit is mounted in a clip holder on the rear of the front panel above the control compartment. On the Radio-Frequency unit, a fuse for the filament transformer is mounted in an extractor type holder toward the rear of the chassis.

1.2 MECHANICAL CONSTRUCTION

1.21 GENERAL

The type TMO Transmitter cabinet is constructed of 3⁄16-inch sheet steel top and bottom and ⅛-inch steel sides. The top, bottom, and sides are electrically welded together to form a cabinet with open front and back. The back opening is covered by a 16-gauge steel cover held in place by sixteen machine screws which screw into threaded holes drilled into the flanged sides.

Knock-out holes have been incorporated in the cabinet walls to accommodate conduits carrying power, control, and audio lines. There are two knock-outs for 1½-inch conduit located near each of the rear corners in the top and bottom. Six knock-outs are provided on the lower rear transverse cabinet member: Two for 1½-inch, two for 1-inch, and two for ¾-inch conduit. In the center of this member an opening is located for connecting the flange of a 2½-inch square duct. This opening is equipped with an internal cover plate attached to the cabinet by three machine screws.

Two additional knock-outs are located in the cabinet to allow two alternate positions for the antenna lead-through bushing provided with the TMO equipment when the antenna lead of the local antenna is connected directly to the transmitter. One of these knock-outs is in the top of the cabinet near the rear center, and the other is in the rear top transverse cabinet member. A rectangular opening 4 by 12 inches is located in the bottom of the cabinet for use when the transmitter is mounted over an underfloor wiring trough. This opening is provided with a 16-gauge cover plate secured to the cabinet bottom by six machine screws which thread into tapped holes in the bottom.

1.22 REMOVABLE CHASSIS

The front panel of each unit is rigidly secured to its chassis by means of flat-head machine screws. Further stiffening is obtained by means of diagonal flanged braces attached to the rear of the front panel and the chassis. A captive screw is located in each corner of the panel to secure the unit chassis assembly to the cabinet when the unit is fully engaged. Two U-shaped pull handles are attached at the sides of each front panel to facilitate withdrawal of the unit from the cabinet for inspection or service. A control compartment for each unit except the power-supply chassis is mounted on the front panel and all compartments are accessible through doors in the front panel. Each door is held closed by means of two door-latches.

The chassis of the TMO transmitter are heavily copper plated after all holes have been punched and the chassis have been formed and welded. The outside of the chassis is painted with a durable gray finish and the inside is painted with a clear finish to prevent oxidation of the copper plate. The front panels are treated with a corrosion-resistant primer; then the outside is finished in black wrinkle and the inside surface with a flat black baking lacquer.

1.23 ROLLER TRACK MECHANISM

Each chassis has its own roller track mechanism consisting of three main parts. The first is the main track which is rigidly attached to the inside of the cabinet. The intermediate track assembly forming the second part fits into the main track. It has three ball-bearing wheels and two hardened steel wheels which together comprise the rolling assembly and acts as a support for the third part, the Z shaped tracks that are attached to the chassis. When a chassis is completely withdrawn from the cabinet, the Z track attached to the chassis is withdrawn almost fully from the intermediate track assembly. This latter assembly, in turn, is almost fully withdrawn from the main track mounted in the cabinet. When this fully withdrawn position is reached, a dog on the intermediate track engages a stop on the Z track, thus limiting further travel of the Z track and chassis.

1.24 CHASSIS REMOVAL

To remove a chassis completely from the cabinet, it is withdrawn to its fully extended position and both stop-dogs, which are accessible through a hole on the outside of the intermediate track, are raised to clear the stop on the Z track. By pulling directly forward on the chassis and supporting it at the same time, the unit can be disengaged from the intermediate track. Each intermediate track can also be removed from the cabinet following removal of the unit chassis, by releasing the stop located toward the rear of the intermediate track and withdrawing the track straight from the cabinet.

1.25 INTER-UNIT WIRING AND PATCHCORD CONNECTORS

The electrical connections to the chassis are made at the rear of each unit by means of a plug and socket connection. The plug, in each case, is mounted on the chassis and consists of a heavy duty multi-terminal connector. The corresponding socket is attached to the socket channel that is mounted across the cabinet rear at each chassis level. Socket wiring is grouped into cables which branch out from the main cable assembly, extending vertically down the inside rear corners of the cabinet. The system of designation of inter-unit cables as applied to Figure 29 will be found described in Section 2.3. The main cable connects to the eighteen-terminal block A, mounted in the bottom of the cabinet. All incoming wiring, such as power, audio and control circuits, is connected to this terminal block. The incoming wiring may be brought into the cabinet through any of the knockouts provided in the walls of the cabinet. The antenna lead-through bushing supplied with the equipment can be mounted either on the top of the cabinet or on the upper transverse member, depending on the placement of the cabinet.

When a chassis is withdrawn from the cabinet, the connections to it are automatically open, thus permitting service work to be done on each assembly without danger of encountering high voltage when the power is on.

If it is desired to operate the equipment with one or more of the chassis withdrawn from the cabinet, patchcord plug and socket connectors are supplied, thus allowing connections to be made between the withdrawn chassis and its socket connection at the rear of the cabinet. In this manner of operation, HIGH VOLTAGE CIRCUITS ARE EXPOSED TO PERSONNEL OPERATING THIS EQUIPMENT AND CARE MUST BE TAKEN TO AVOID CONTACT WITH THESE CIRCUITS.

1.26 VENTILATING SYSTEM

All control compartments with the exception of that on the load coil chassis are essentially airtight behind the panel to prevent air from the blower being forced into them. The Load Coil control compartment has screened openings on the sides and top that permits the air drawn in by the blower to be forced through this compartment and out through its access door. The fine-mesh screen prevents insects from entering the cabinet.

The dust filter located in the Power-Supply Unit consists of oil-impregnated spun-glass fibers mounted in a cardboard frame. If impurities are present in the air, they are collected by these glass fibers, allowing only clean air to enter the cabinet. The dust filter is accessible from the front by removal of the four captive screws which attach the perforated cover to the front panel.

1.3 ELECTRICAL THEORY OF OPERATION

1.31 CRYSTAL OSCILLATOR

The oscillator, which employs a type 6V6G tube, V8, is located in a shielded compartment which houses the crystal and associated oscillator circuit components. The circuit operates as a conventional Miller oscillator with the crystal connected in the control grid circuit to ground. Grid bias voltage is generated across a grid resistor shunted across this crystal circuit. A parallel-tuned tank circuit in series with the plate circuit is tuned to the crystal frequency. Additional grid bias is generated across the cathode resistor of this stage. Since the tube is operated as a pentode, the screen is operated at high d-c voltage supplied through a dropping resistor from the plate supply.

Oscillation is maintained by feed back from plate to control grid through the inter-element capacity of the tube. Plate and screen voltage is applied to this stage when the FILAMENT switch in the Modulator control compartment is ON. Tuning of the plate tank circuit of the oscillator is accomplished by means of a variable air capacitor. The tuning range is continuous from 200 to 400 kilocycles.

1.32 BUFFER AMPLIFIER

Following the oscillator stage is another type 6V6G tube, V9, employed as a buffer amplifier. This tube and its associated plate tank are located in the shielded compartment with the oscillator. The buffer tube operates as a beam power pentode in class C. The grid circuit is loosely coupled to the oscillator plate tank by means of a small mica capacitor. Combination fixed and grid leak bias is employed in the buffer stage. The cathode is grounded directly. Sufficient fixed bias is applied to limit the plate and screen dissipations to less than maximum allowable in the event of loss of radio-frequency voltage at the control grid. The plate of the buffer is series-fed through a parallel-tuned tank circuit. This tank is fixed-tuned to a frequency of approximately 283 kilocycles by means of a mica capacitor. A split secondary winding is closely coupled to the plate tank to provide radio-frequency excitation for the power amplifier control grids. To broaden the resonance characteristic of the buffer tank circuit, the secondary winding is loaded with resistance shunted directly across the winding.

This provides sufficient radio-frequency voltage for the next stage over the operating range from 200 to 400 kilocycles without causing over-excitation at 283 kilocycles, the resonant frequency of the buffer tank circuit. Plate voltage is obtained from the high voltage (866A) power supply through a voltage-dropping resistor. Screen voltage is also obtained from this supply through an additional dropping resistor. A resistor R30 connected from buffer screen to ground allows sufficient bleeder current to flow through R23 and R29 to limit the screen and plate voltages at the tube to safe values in the event of loss of radio-frequency voltage on the control grid.

1.33 POWER AMPLIFIER

The power amplifier uses two type 807 tubes, V10 and V11, parallel connected in a Class C amplifier circuit. Combination grid leak and fixed bias is used in this stage, the fixed bias being of sufficient value to limit the plate and screen dissipations to less than the maximum allowable in the event of loss of radio-frequency excitation at the control grids. The plate power for this stage is obtained from the high-voltage supply system through the secondary of the modulation transformer. A low resistance is used between the plates of V10 and V11 to prevent parasitic oscillation. The plate circuit consists of a parallel-tuned series-connected tank. The inductive branch of this tank is divided into two sections: A variometer in series with a fixed inductance, each wound on separate forms and having a minimum coupling to each other. The capacitive branch of the tank comprises two fixed mica capacitors C32 and C33. Both capacitors are used in parallel when the operating frequency lies between 200 and 283 kilocycles. Between 283 and 400 kilocycles, capacitor C33 is removed from the circuit by means of a link switch S8. For each connection of the tank capacitors, the variometer resonates the tank circuit throughout the respective range. Screen voltage is obtained through a series voltage-dropping resistor from the plate supply.

Two indicating instruments are mounted on the Radio-Frequency unit. One is designated OSC. PLATE CUR. and indicates the 6V6G oscillator plate current. The second instrument is designated PA PLATE CUR. and indicates plate current to the 807 power amplifier tubes.

1.34 OUTPUT CIRCUIT

1.341 LOCAL ANTENNA

The fixed-inductance coil in the inductive branch of the power amplifier plate tank circuit is closely coupled to a secondary winding wound concentrically on the same form, and formed from bare tinned copper bus. The output circuit is supplied with radio-frequency power from this winding, connections being made by two clips attached to flexible leads. When the type TMO transmitter is used with a local antenna, the Antenna Load Coil Unit is situated in the cabinet above the Radio-Frequency Unit. One side of the output winding is grounded through one of the flexible clip leads, while the other side of the output circuit is carried up to the Load Coil Unit by means of radio-frequency plugs and sockets mounted on ceramic insulators.

A thermocouple-type radio-frequency ammeter is employed in the output circuit between the output winding in the tank circuit and the load coil to indicate the antenna current. The antenna load coil consists of a variometer wound with litz wire to keep radio-frequency losses to a minimum. Radio-frequency current flows through the antenna ammeter to the rotor, then the stator and thence through the antenna contactor to the ceramic-insulated plug and jack assembly. A tinned copper bus lead connects the jack to the antenna lead-through bushing mounted in either the top or back of the cabinet.

The load coil is employed to tune capacitive antennas to resonance, which allows maximum antenna current to flow. Since a wide range of antenna capacities may be encountered, the stator winding has nine taps brought out to a terminal board mounted adjacent to the coil. This allows a rough adjustment of the load coil inductance, while the fine adjustment is made with the rotor. Figure 26 gives curves of frequency versus load coil taps for three values of antenna capacity, to aid in selection of the correct tap.

A flexible connection is used between the load coil terminal strip and the antenna contactor. The solenoid of this contactor is energized by the closing of the FILAMENT switch in the Modulator Control compartment. In section 1.38, Control Circuits, a further discussion of this solenoid circuit is made.

1.342 REMOTE ANTENNA

In some installations, it will be impossible to erect a suitable antenna directly on the airport either because it will constitute a hazard to aircraft or because its appearance is considered objectionable. In such cases a remote antenna must be erected. The Antenna Load Coil unit is removed from the transmitter and placed in a housing at the base of the remote antenna.

The output circuit from the power amplifier tank which is brought up to radio-frequency jack J8 on the top socket channel is connected to the center radio-frequency jack J10 by means of an auxiliary capacitor assembly C35 and C36. This assembly has two plugs which engage the two jacks J8 and J10. The center conductor of the coaxial transmission line, which supplies radio-frequency power to the remote Load Coil Unit, connects to J10, while the outside conductor is grounded.

This capacitor assembly, C35 and C36, functions to tune the output circuit to resonance to allow maximum radio-frequency power transfer. Both capacitors are required if the operating frequency is in the low-frequency range of 200 to 283 kilocycles. In the high-frequency range between 283 and 400 kilocycles, capacitor C35 is removed from the circuit by means of a bus-bar link. These capacitors are not necessary when the Load Coil unit is located at the transmitter since the inductance of the output winding combines with the load coil inductance to tune the capacitive local antenna to resonance.

The inductance of the output winding is sufficient, when the capacitors C35 and C36 are employed, to furnish 47.5 watts of radio-frequency power to a 70-ohm load, over the range of the transmitter. The coaxial transmission line serves as the load on the tank circuit, and functions to deliver radio-frequency power to the remote antenna.

A portion of the load coil near the "ground" end, i.e., the end nearest the antenna ammeter, is wound with bare tinned copper wire. The transmission line is brought into the remote housing to a terminal board which connects to a ceramic-insulated jack. This jack engages a plug on the Load Coil Unit chassis which connects to the bare-wire winding on the end of the load coil by means of a flexible lead and clip terminal. A sufficient number of bare turns are provided to permit a 70-ohm, purely-resistive termination of the transmission line for any operating frequency from 200 to 400 kilocycles, with antenna resistances of from 5 to 20 ohms. This matching section is not employed when the Load Coil Unit is used at the transmitter with a local antenna. Wiring changes that are necessary to insert this winding into the circuit are indicated in Section 3.611, Wiring Changes.

When the matching section is used as a termination for the transmission line connected to the transmitter, the rest of the load coil still functions to tune the capacitive antenna to resonance as with a local antenna.

1.35 SPEECH AND INPUT CIRCUITS

The audio-frequency input system of the type TMO equipment employs an input transformer with tap connections on the primary to provide a nominal input impedance of either 600 or 1200 ohms. The 1200 ohm winding is provided to take care of an installation where a 600 ohm line feeds two TMO Transmitters, in which case the 1200 ohm primary of each input circuit is paralleled giving a resultant of 600 ohms. This primary is not connected to ground, for use with ungrounded telephone lines, if necessary. The secondary of the input transformer, which is loaded with resistance to reflect the correct primary impedance, furnishes audio-frequency voltage through a potentiometer-type attenuator to the grid of a 6SJ7 tube, V4, operated as a pentode voltage amplifier. This stage is resistance-coupled to a type 6V6G tube operating as a triode driver for the modulator stage.

An equalizer in the plate circuit of the driver stage sharply attenuates audio-frequencies above 4000 cps. At 5000 cps the response is down 5 decibels below that at 4000, while at 6000, the response is reduced to more than 10 decibels below that at 1000.

1.351 TONE OSCILLATOR CIRCUIT

The 6V6G audio driver tube is made to oscillate at approximately 1020 cps to provide tone modulation of the carrier. This is accomplished by feeding back audio voltage of the proper phase from the secondary of the driver transformer through mica capacitor C13 to the grid resistors R8 and R9 of the 6V6G driver tube. C13, R8, R9 and the inductance and capacity of the driver transformer secondary determine the frequency of oscillation.

The feedback is controlled through the tone switch key S4 in the modulator control compartment, or remotely by means of contacts on tone relay K4. A potentionmeter R40 is shunted across the secondary of the driver transformer when switch S4 or relay K4 is closed, to control the amplitude of oscillation and hence the degree of modulation. This adjustment also provides a means of compensation for differences existing between 6V6G tubes when replacements occur.

1.36 MODULATORS

Two type 807 tubes are employed as modulators operating Class AB2. Fixed bias to the grids is applied through the secondary of the driver transformer. Since this modulator is capable of being operated with either Type TMO or TUI equipment, as described in Section 1.132, Modulator Unit, the screen-circuit bleeder resistance to ground must be changed accordingly. This bleeder resistance R12 is employed to keep the modulator screen voltage essentially constant regardless of audio voltage drive. Modulator plate current is indicated by a meter designated MOD. PLATE CUR.

Because of the relatively high ratio of the audio modulating frequency in comparison to the carrier frequency in this range, sideband frequencies, generated in the process of amplitude modulating the carrier, are attenuated in the power amplifier tank and antenna circuit. The upper and lower sideband frequencies with a 4000 cps audio modulating frequency are relatively so far removed from the carrier frequency that the sharpness of the resonance characteristic of the tank and antenna load circuit, i.e., its selectivity, causes their attenuation. At higher radio-frequencies, this attenuation is not so severe since the ratio of audio to radio-frequencies becomes increasingly smaller. An external equalizer, not supplied with this equipment, is employed in the audio input circuit to the TMO Transmitter to partially compensate for this sideband-frequency attenuation. Adjustment of this circuit is discussed under section 4.16 "MAJOR" servicing of TMO Transmitters.

1.37 POWER

1.371 LOW-VOLTAGE SUPPLY

The low-voltage supply consists of a type 5Z3 tube, V3, operating in a full-wave rectifier circuit working into a two-section choke-input filter. The output voltage of this supply is approximately 280 volts. Power is supplied to the crystal-oscillator tube V8, to the audio amplifier tube V4 and the audio driver tube V5.

1.372 BIAS SUPPLY

Bias voltage is generated across two series resistors R7 and R17 between the center tap of the high-voltage winding of the low-voltage plate transformer and ground. The full bias voltage obtained from this supply is approximately 60 volts and is supplied to the grids of the power amplifier tubes. Lower bias voltage of approximately 24 volts is obtained across resistor R17 and applied to the modulator and buffer stages.

1.373 HIGH-VOLTAGE SUPPLY

The high-voltage plate-supply system uses two type 866A tubes, V1 and V2, operating in a full-wave rectifier circuit working into a single-section choke-input filter. Two taps to be selected by TUNE-OPERATE switch S5 in the Modulator control compartment are provided on the primary of the plate transformer to provide an output voltage from the power-supply of approximately 280 volts for TUNE and 500 volts for OPERATE. The high-voltage plate supply furnishes plate power for the modulator tubes V6 and V7, for the buffer tube V9 and also plate power for the power amplifier tubes V10 and V11.

1.38 CONTROL CIRCUITS

Figure 30 is a simplified diagram of the a-c control circuits. The a-c line is connected to terminals 7 and 8 on terminal board A in the bottom of the cabinet. These terminals connect with the line fuses F1 and F2. From this point, voltage is applied to the contacts of plate and filament contactors K2 and K3 respectively. The solenoid of plate contactor K2 is energized through PLATE test key switch S7. This contactor may also be controlled from a remote point by means of primary relay K1, which is a telephone-type relay with solenoid connections brought out to terminals 1 and 2 on the terminal board A in the bottom of the cabinet. This circuit connects with the relay power supply and microphone press-to-talk switch on the microphone at the control point. The primary relay K1 is provided with a form C (break-make) contact assembly. For control tower operation, the solenoid of K1 is normally energized which opens the plate contactor K2 solenoid circuit. When the press-to-talk switch on the microphone is operated, this opens the primary relay K1 which closes the plate contactor K2 applying voltage to the primary of the plate transformer T2 through the TUNE-OPERATE switch. When it is desired to operate the type TMO Transmitter so that plate contactor K2 is energized when primary relay K1 is energized, a change in the wiring to contacts of K1 must be made. When the TUNE-OPERATE switch is in the TUNE position, additional turns are inserted in the primary of plate power transformer T2. This reduces the plate voltage applied to the modulator, buffer, and power amplifier stages, to prevent damage to tubes during tuning.

The solenoid of filament contactor K3 is energized through FILAMENT switch S6. Connections to this switch are brought out to terminals 13 and 14 on terminal board A to allow the filament circuit to be controlled from a remote point. Filament contactor K3 applies voltage to rectifier filament transformer primary T1, low-voltage plate-power transformer primary T3, filament transformer primaries T7 and T8, blower B1, antenna contactor K5 and indicator light I1.

Since the type TMO Transmitter is designed to operate at ambient temperatures as low as -10° Centigrade, dependable functioning of the mercury-vapor rectifier tubes, type 866A, at this low temperature must be assured. This is accomplished during winter months by keeping the filaments of rectifier tubes V1 and V2 lighted at all times when line voltage is applied to terminals 7 and 8 on the terminal board A, regardless of whether FILAMENT switch S6 is ON or OFF. A LOW-NORMAL TEMPERATURE link switch S2 in one side of the primary of rectifier filament transformer T1 allows a continuous application of voltage to the primary of T1 in the LOW position during the cold season, while in the NORMAL position, to be used during the rest of the year, voltage is applied to the primary of T1 through filament contactor K3 controlled by FILAMENT switch S6.

Since the majority of type TMO Transmitters are operated in control towers in conjunction with a standby transmitter of the same type, an interlock circuit is provided to connect the antenna or transmission line to the transmitter actually in operation. Antenna contactor K5 contains three sets of contacts, one set of which is normally closed and connected in the interlock circuit. When two TMO Transmitters are used together as active and standby equipments, closing the FILAMENT switch on the active transmitter will close its K5 relay since one side of the solenoid is connected through the interlock contacts of K5 on the second or standby transmitter. Closing of K5 on the first equipment opens the interlock contacts on this contactor preventing the closing of K5 on the second transmitter since its solenoid circuit is connected through the interlock contacts of K5 on the first transmitter. Thus, the transmitter first turned ON will remain connected to the antenna even though the second transmitter is turned on for testing.

When a single type TMO Transmitter is being operated with no standby equipment, the solenoid circuit of K5 must be completed by means of a jumper connection between terminals 11 and 12 on terminal board A.

Thermostat switch S1 is in series with one side of the blower motor circuit. Contacts on this switch remain closed for all ambient temperature above 20° Centigrade.

1.4 MODIFICATIONS

During the course of manufacture of the Type TMO Transmitter under the two contracts to which this Instruction Book applies, certain modifications have been made, resulting in improved performance. **The following tabulation lists these modifications with a brief description of the purpose and reason in each case:**

1. **On TMO Transmitters Serial No. 1 to 50 inclusive,** a narrow top shield over the oscillator compartment on the Radio-Frequency Chassis was supplied. Later, it was found that increasing the width of this shield to cover the whole compartment improved the stability of the power amplifier stage. The wide shield was shipped to all facilities that received one of the first fifty equipments.
2. **On the first fifty equipments,** the lead with the red and green tracer in the Modulator chassis connected between mica capacitor C13 and TONE key switch S4 was laced into the cable which was connected through the grommetted hole on the right side of the Modulator chassis. It was found that unbalance in the audio voltage applied to the grids of the Modulator resulted from this routing. Consequently, this red-green tracer was removed from the cable and carried to the grommeted hole between capacitors C15 and C16. Instructions for making this change, together with a length of lead of the correct length, were supplied to all facilities involved.
3. **On TMO Transmitters serial numbers 1 to 132,** the tone frequency was approximately 600 cps. When it was decided to change the tone frequency to approximately 1020 cps, it was necessary to change certain components in the Modulator Unit. Resistor R8 was changed from 470,000 to 390,000 ohms. Resistor R9 was changed from 150,000 to 160,000 ohms. Capacitor C13 was changed from .0045 microfarad to .0035 microfarad. Capacitor C9, which was connected from the junction of R8-R9 to ground, was removed. A kit of replacement parts, along with instructions, was sent to all facilities involved. **On transmitters above serial number 132, the change in tone frequency was made at the factory.**
4. To more closely control the depth of modulation of the carrier with tone frequency, a potentionmeter R40 was added. This variable resistance was connected in such a manner that when either TONE key S4 or tone relay K4 was closed the potentionmeter would be shunted across the secondary winding of audio driver transformer T5 to limit the audio voltage appearing across this winding. **A kit of parts with instructions were sent to facilities which had Type TMO Transmitters numbering from 1 to 168.** This kit was sent along with the kit for change number 3 to facilities where both changes were required. **On transmitters above serial number 168,** these changes were incorporated at the factory.

The following changes on all Type TMO equipments above serial number 168 were made at the factory:

1. The extractor-type fuse holders for fuses F3, F4, F5, F6, F7, and F9 were changed from Littelfuse type 1075A to Bussman type HKM.
2. The blower motor B1 was changed from a General Electric type KSC to an A. G. Redmond Model 123 type R.
3. The blower fuse F3 was changed from a ¾ ampere Slo-Blo to a 1 ampere Slo-Blo.
4. Fuse F7 was changed from a ½ ampere Slo-Blo to a 1 ampere 3AG.

5. Dials for tuning controls were changed to a Crowe type 294 on equipments with serial numbers 169 to 280, inclusive.
6. Dial locks were changed to a Millen Type 10050.
7. The oscillator coil winding was changed to a 4 pi construction using litz wire.
8. The load coil unit chassis is modified in that the cut-out space under the load coil has been lengthened at the left end. This necessitated a longer mounting support for the load coil at the left end.
9. The numbering of contacts on chassis plugs P1 and P5 on the Power-Supply Unit and Radio-Frequency Unit respectively were changed to number from 7 to 12 to correspond with the numbering on sockets J1 and J5
10. On the Power-Supply Unit, the lead with the black tracer which was connected between K2 and K3 was changed to connect between K2 and F1. Electrically, the circuit remains the same. **See figs. 30 and 31.**
11. On the Power-Supply Unit, the lead with the red and yellow tracer which was connected between blower motor socket J13 and indicator light I1 was changed to connect between blower motor socket J13 and K3. Electrically the circuit remains the same. **See figs. 30 and 31.**
12. On the Modulator Unit, the lead with the brown and yellow tracer connected between terminal 5 on the primary of filament transformer T7 and terminal 11 on P3 was rerouted to connect between terminal 3 on the primary of low voltage plate transformer T3 and terminal 11 on P3. **See fig. 32.**
13. On the Modulator Unit one connection of capacitor C14 was changed from ground to number 2 terminal on the primary of audio driver transformer T5. This removed the d-c voltage stress on this capacitor. **See fig. 32.**
14. Several changes in wiring cables were made on the Radio-Frequency Unit. A second wiring diagram fig. **33B** is supplied.

2. INSTALLATION

2.1 GENERAL

Since the type TMO Transmitter was primarily designed for installation in control towers where space accommodations are not uniform, definite instructions regarding placement of cabinets, knockouts to be used, and methods of cabinet mounting cannot be given here. Several bulletins published by the CAA may be used in connection with the installation and adjustment of the type TMO Transmitter. These bulletins are as follows:

- Installation Instructions for Airport Control Tower Equipment—Published April, 1943.
- Addendum to Installation Instructions for Airport Control Tower Equipment—Published September, 1943.
- Installation Instructions for Class MHT Facilities—Published July, 1943.

2.2 UNPACKING

The transmitter is shipped in six boxes:

1—Transmitter cabinet and intermediate track assemblies.
2—Power-Supply Unit.
3—Modulator Unit.
4—Radio-Frequency Unit.
5—Antenna Load Coil Unit
6—Two crystals, instruction book, test data, antenna bushing, seven patch cords and spare fuses. In some shipments only one crystal is included, with the second following at a later date. Transmitters for use at airport traffic control towers receive only one crystal.

Open each box carefully, removing the top cover screws, then the front. Remove each unit from its box and inspect carefully for damage that might have occurred during shipment.

1. Remove binding tapes from the intermediate tracks in the cabinet.
2. Remove blocks and tie-down tape from blower motor.
3. Remove tape from contactors on Power-Supply Unit.
4. Remove tapes from plate leads on Power-Supply Unit.
5. Remove tapes from Radio-Frequency Unit plate leads.
6. Remove tape from Load Coil Unit.
7. Unlatch doors, loosen dial locks, and inspect dials for any damage.
8. Inspect cables to be sure that all terminal connections are tight.
9. Be sure that all controls such as dials, switches and test keys work properly.

2.3 ASSEMBLY

The empty cabinet should be located before placement of the units in their proper position and situated such that a minimum space of thirty inches in front is provided to allow removal of the individual unit for inspection (see Fig. 37). The back cover should be removed from the cabinet to allow inspection of the wiring and installation of the antenna bushing in its proper knockout hole. After the cabinet has been located, it should be fastened down with lag screws placed through the holes provided in the bottom of the cabinet. **This precaution is absolutely necessary to prevent the equipment from overturning when two or more units are withdrawn from the cabinet.**

The antenna bushing should be installed in in either of the alternate positions provided in the top or rear of the cabinet. Other knockouts or plates should be removed to bring in power, control and audio input wiring which connects to terminal block A, mounted in the bottom of the cabinet:

The following is a tabulation of the proper connections to terminal block A, mounted in the bottom of the cabinet:

Terminal No.	Circuit Connection
1-2	Plate primary relay K1
3-4	Audio input
5-6	Tone relay control
7-8	105-120 volts 60-cps input power
9-10	Interlock contacts
11-12	Interlock
13-14	Filament contactor control
15	Ground
16-17-18	No connection

To install the chassis in their proper places in the cabinet, the intermediate tracks should be pushed all the way in; then the rear edge of each Z-track should be inserted between the hook and the top of the front bearing wheel on the intermediate track assembly. The unit is now pushed in to a point where the hooks on the intermediate track assembly drop past the stops on the Z-track. Withdrawing the unit from the cabinet now pulls out the intermediate track system in proper relation to the main track assembly and the chassis track. Slowly pushing the unit assembly into the cabinet should result in an easy, rolling motion of the two assemblies, and a complete positioning of the unit front panel against the cabinet. The last inch of travel into the cabinet should require slight additional pressure on the front panel since the rear contacts are positioning themselves in the socket which offers some resistance to the plug.

The sockets on the channels have been placed in proper position at the factory so that they are in perfect alignment with the plug on the chassis. If, for any reason, it is necessary to reposition this assembly, the socket should be re-adjusted, not the plug on the unit chassis. This can be accomplished by loosening slightly the mounting screws to allow a movement of the socket in its channel. This should be done with the unit slightly withdrawn from the cabinet. Then the unit is slowly pushed into the cabinet until it makes contact with the socket. With correct relation existing between the socket and plug, the socket mounting screws are again tightened.

2.4 WIRING DESIGNATION

The code used on the schematic wiring, diagram for identifying inter-unit cabling connections and to designate the type of wire construction employed in the inter-unit cabling is as follows:

All socket terminals are numbered and correspond to the clip connection on their respective unit plug connectors. An arrow opposite each numbered terminal indicates the routing of each cable connection to terminals on other inter- or intra-unit sockets. In order to identify the routing of the connection to sockets within a unit or in different units, each terminal to which an inter-connection is made is indicated by an arrow prefixed by a "unit" letter designator to identify the unit socket terminus, and also an "item" letter to designate to which socket within the unit the connection is made.

Thus, starting with the bottom terminal block, which is designated Unit A, the following "unit" letters identify unit routing of interconnecting leads: B for the Power-Supply Unit, C for the Modulator Unit, D for the Radio-Frequency Unit, and E for the Load Coil Unit; and the additional "item" letters used to distinguish between sockets in the same unit are X, Y, and Z. For example at the Power-Supply Unit, the arrow at terminal 10 on socket X indicates that the connection is routed to terminal 8 of the Y socket in Unit C, and therefore, carries the designation CY8 at the BX socket in the Power-Supply and BX10 at the CY socket in unit C. Note also that another connection is routed from CY8 to DX7.

In addition to the terminus connection at BX10, it will be noted that immediately above the arrow line another code group appears. This code, consisting of one letter and two numerals, is used to afford instant recognition of the wire type and to facilitate tracing of circuits. The letter indicates the wire construction, the first number indicates the insulation color and the second number indicates the color of the tracer. These letter-number groups are coded using combinations of the following legends:

INSTALLATION

WIRE CONSTRUCTION LEGEND

Letter	B & S GA	Stranding	Installation	Class
A	18	7/26	1000	Aircraft
B	18	7/26	1000	Shielded
C	18	7/26	3000	Aircraft
D	16	26/30	1000	Aircraft
E	14	42/30	1000	Aircraft

COLOR CODE

0 Black
1 Brown
2 Red
3 Orange
4 Yellow
5 Green
6 Blue
7 Violet
8 Slate
9 White

Thus, the letter-number combination C92 at terminal CY8 indicates the type of construction of this inter-unit cable which, in this case, is #18, 3000 volts, stranded aircraft wiring and is readily identified by its fabric covering of a white body with a red tracer.

The cabling connections of the unit wiring diagrams are coded with color abbreviations preceded by symbols of parts to which the leads connect; for example in Fig. 31 Wiring Diagram Power-Supply Unit, the lead connecting terminal 1 of T2 to a contact on K2, is designated K2 R-B indicating that the lead is white with a red and blue tracer.

2.5 FUSE AND TRANSFORMER CHECK

All fuses should be examined and their rating checked with the following tabulation. The fuses used in the equipment with the part number of the fuse and unit in which these are located are as follows:

Part No.	Fuse Rating (Amp)	Circuit	Unit	
F1	6	Line	Power	
F2	6	Line	Power	
F3	¾ Slo-Blo	Blower	Power	S/N 1-168
F3	1 Slo-Blo	Blower	Power	above S/N 168
F4	1	High-voltage rectifier filament transformer	Power	
F5	3	High-voltage plate transformer	Power	
F6	1	Modulator filament transformer	Modulator	
F7	½ Slo-Blo	Low-voltage power transformer	Modulator	S/N 1-168
F7	1	Low-voltage power transformer	Modulator	above S/N 168
F8	¼	Modulator plate	Modulator	
F9	1	Radio-frequency filament transformer	Radio-Frequency	

The type TMO Transmitter is shipped with all primary connections to transformers placed on the 120-volt tap, and line voltage at the point of installation should be measured to determine if it is within 5 volts of this rating. All filament transformers are provided with 105, 110, 115 and 120 volt taps. Low-and high-voltage plate power transformers are provided with 110 and 120 volt taps only. The following is a tabulation of line voltages and transformer connections for the plate and filament transformer primaries:

Transformer	105 Volts	110 Volts	115 Volts	120 Volts
Rectifier filament T1	1-2	1-3	1-4	1-5
High-voltage plate T2 TMO	1-2	1-2	1-3	1-3
High-voltage plate T2 TUI	1-4	1-4	1-5	1-5
Low-voltage plate T3	1-2	1-2	1-3	1-3
Modulator filament T7	1-2	1-3	1-4	1-5
Radio-frequency T8	1-2	1-3	1-4	1-5

2.6 REPACKING

To repack the type TMO transmitter for shipment the four unit chassis are removed from the cabinet. Intermediate tracks are left in place and tied with heavy string or light cloth tape. Vacuum tubes should be removed from the unit and packed in cartons. Plate leads on the power and radio-frequency units should be tied down. Plate and filament contactors on the power-supply units should be taped closed. Dials on the radio-frequency and load coil units should be locked tightly, and doors on all units tightly closed by means of the door latches. The load coil in the top unit should be tied down by means of cloth tape. The blower motor should be blocked in place so that it is not allowed to move around on its shock absorbers during shipment.

The instruction book, test data, antenna bushing, two crystals, patch cords and spare fuses should be packed in one box. Disassembly of the cabinet should include removal of the incoming power, control and audio leads from the terminal block A, and removal of the lag screws through the bottom of the cabinet. Each unit should be placed in an individual box, and the cabinet crated separately.

3. TRANSMITTER ADJUSTMENT PROCEDURE

3.1 PRELIMINARY

When all connections have been made to terminal block A on the bottom of the cabinet, and filament and plate transformer primary taps have been adjusted to correspond to the existing line voltage, the unit chassis may be installed in their respective positions in the cabinet. Vacuum tubes can then be placed in their correct sockets and one of the quartz crystals supplied should be inserted in its position on the radio-frequency chassis. If a local antenna is used, the lead-in is connected to the antenna lead-through bushing located either at the top or top rear of the cabinet.

3.12 PRECAUTIONS

1. Do not withdraw chassis units to their fully extended position until the transmitter cabinet and base upon which it rests are securely lagged to the floor.
2. Unless primary relay K1 is energized by application of d-c voltage to terminals 1 and 2 on terminal board A, primary voltage is applied to the high-voltage plate transformer by plate contactor K2 as soon as the FILAMENT switch in the modulator control compartment is turned ON, or the filament control circuit closed remotely through terminals 13 and 14 on terminal board A.
3. The zero correction screw on each meter **should not be rotated more than 70°** in either direction from the vertical position of the screwdriver slot when making zero corrections, otherwise the pin on the opposite end of this screw will be broken.
4. The power amplifier plate circuit should not be tuned when the TUNE-OPERATE switch is in OPERATE position. Unless the circuit is very near resonance, the power amplifier tubes draw excessive plate current which might result in damage to these tubes.
5. Maximum plate current should not be exceeded by excessive coupling of the output circuit to the power amplifier tank, since shortening of life and probable damage to the power amplifier tubes will result.

3.2 CRYSTAL OSCILLATOR STAGE

With all unit chassis in place, and with power supplied to the incoming power leads terminating in the bottom of the cabinet, the FILAMENT switch located in the modulator control compartment should be turned ON. Rectifier tubes V1 and V2, when first placed in service, require an initial warm-up period of 30 minutes. With the FILAMENT switch ON, power is applied to the crystal oscillator stage and the crystal plate circuit should be tuned to resonance by means of the OSC. PLATE dial in the control compartment of the radio-frequency unit. Resonance is indicated by a minimum reading of the OSC. PLATE CUR. meter on the radio-frequency unit front panel.

It may be found that some crystals supplied with this equipment will have two resonant points. The second undesired resonant point is caused by a frequency generated by the crystal which is a function of its width, in contrast to the desired frequency which is a function of thickness. This second point occurs on the low-frequency side of the crystal nameplate frequency and is far enough removed from the operating frequency to cause no confusion. The resonant dip in oscillator plate current is less at this incorrect frequency resonant point than at the correct or nameplate frequency resonant point. Reference should be made to the crystal oscillator dial calibration chart, Figure 23, if any doubt exists as to the correct resonant point. For instance, if the nameplate crystal frequency is 278 kilocycles, the correct resonant dial tuning point is approximately 49.

3.3 BUFFER AMPLIFIER

No tuning adjustment is required on the buffer amplifier stage since the plate tank circuit is tuned to a resonant frequency of approximately 283 kilocycles by means of a fixed capacitor C27.

3.4 POWER AMPLIFIER

The radio-frequency unit should now be withdrawn from the cabinet and the link switch S8 set in a position to correspond to the operating frequency marked on the nameplate of the crystal. Set the TUNE-OPERATE switch in the modulator control compartment to TUNE. **If a local antenna is used, withdraw the load coil unit from the cabinet far enough to disengage the contacts at the rear of the chassis.** Following the 30-minute warm-up period for the rectifier tubes, depress the PLATE test key and **rotate the PA PLATE dial until minimum current is observed on the PA PLATE CUR. meter.** A chart, Fig. 25, gives an approximate calibration of the PA. PLATE DIAL. This current should be approximately 20 milliamperes. Move the TUNE-OPERATE switch to the OPERATE position with PLATE test key OFF. Depress the PLATE test key and re-check the PA. PLATE tuning point.

Selection of the proper turn on the secondary winding L10, to which the coupling clip is attached, is dependent upon the resistance of the antenna used as well as the frequency of operation. Charts, Figures 24A and 24B indicate the number of turns required for the frequency used for several values of antenna resistance from 5 to 20 ohms and a transmission line impedance of 70 ohms. These charts indicate only an approximate setting of the taps. The power amplifier plate current, which should not exceed 166 milliamperes, determines the final setting.

3.5 ANTENNA LOAD COIL

The Load Coil Chassis should now be withdrawn from the cabinet and the flexible lead on the load coil terminal strip placed on the correct tap as given approximately by a chart, Figure 26, of load coil taps for various frequencies and antenna capacities. Replacing the load coil unit in the cabinet, the PLATE key is depressed and the ANTENNA LOAD dial rotated until a maximum antenna current is indicated by the ANT. CURRENT meter located on the front panel of the top unit. Tuning for a maximum reading of this meter should also result in a maximum reading on the PA. PLATE CUR. meter. If the PA. PLATE CUR. meter reading is greater than 166 milliamperes, the coupling turns on the radio-frequency transformer L10 should be reduced. This is accomplished by withdrawing the radio-frequency unit from the cabinet and moving the front clip toward the rear of the coil. Such an adjustment is made in steps until the correct plate current results. After each change in the tap position on the radio-frequency secondary L10, the antenna load coil must be slightly retuned for a maximum reading of both ANT. CURRENT and PA. PLATE CUR. meters.

If it is found that the tap selected on the load coil will not give a resonant reading on the ANT. CURRENT meter, a tap adjacent to the one chosen should be tried. If the ANTENNA LOAD coil tuning dial causes a rise in antenna current but not a resonant condition as the low-numbered end of the dial is reached, it indicates that the next lower number tap should be employed. Conversely, if a resonant condition is approached when the control is turned toward the high numbered end of the dial, the next higher number tap should be used. Tuning of the antenna load coil should always result in an absolute resonant condition. This condition must exist before the proper coupling tap on the secondary of the radio-frequency transformer L10 is finally selected.

The ANTENNA LOAD dial reading, antenna load coil taps and the ANTENNA CURRENT meter indication can not be recorded on the TUNING CHART until the equipment is completely installed and operating into the particular antenna at the point of installation. Therefore this data should be filled in at the station upon completion of installation and correct tuning. In general, long antennas will require less load coil inductance than short antennas.

3.6 REMOTE ANTENNA INSTALLATION

3.61 LOAD COIL UNIT CHANGES

3.611 WIRING CHANGES

Adjustments under section 3.5 apply when a local antenna is employed; that is, one whose lead-in was connected directly to the antenna bushing. If the antenna is located at a remote point from the transmitter, a co-axial transmission line with a characteristic impedance of 70 ohms should be employed to connect the transmitter to the antenna; however, it is necessary to make several changes in the Load Coil Unit, see figure 34, before it is removed to a remote position, as discussed in section 1.134. Figure 35 is a schematic illustrating completed changes for a remote installation. The changes necessary are as follows:

1. The number 12 gauge bus-lead, connected from one terminal of the ANTENNA CUR. METER to the front rotor terminal on the load coil is removed from the rotor terminal and connected to the unused lug on the right end of the matching section.
2. The left end of the matching section coil, i.e. the end nearest the rotor, is connected by means of a short jumper of number 12 gauge bus wire to the front rotor bearing connection from which the meter lead was removed. The antenna contactor K5, normally located on the load coil chassis is removed and reinstalled on the radio-frequency unit in the position occupied by the phenolic terminal board at the rear of this chassis.
3. The flexible clip coupling lead connected to the ceramic bushing on the phenolic terminal board mounted on the radio-frequency unit is removed from the bushing, and the four cable leads connected to the terminals on this board are then removed along with the mounting screws holding the board to the chassis. The phenolic terminal board is now mounted on the load coil unit with the three metal spacers holding the board above the chassis in a position identical with the former placement of the antenna contactor K5.
4. The ceramic bushing is reassembled in the opposite hole in this board and the flexible coupling lead previously connected between the load coil terminal strip and the antenna contactor is attached to the top of the ceramic bushing assembly. The bus lead extending from P10 is attached to the bottom of the ceramic assembly. The four leads that were connected to the antenna contactor solenoid and interlock contacts are now placed on the board terminals. Figure 35 will be of assistance in making this changeover.
5. Antenna contactor K5 should now be mounted on the radio-frequency unit and the leads connected in their respective positions. The flexible clip coupling lead is attached to the front contact arm on top of the contactor and the bus lead extending from P7 is attached to the rear contact arm on the bottom of the contactor.
6. With the load coil unit installed at the remote antenna, the 70-ohm line is connected with the center conductor terminating inside the cabinet at socket J10 and the outside conductor or shield grounded at the transmitter.

3.612 TRANSMISSION LINE SERIES CAPACITORS

Antenna capacitors C35 and C36 mounted on a strip with two plugs, are connected between socket J8 and J10 as shown on Figure 35. If the operating frequency is between 200 and 283 kilocycles, both capacitors are connected in parallel. Capacitor C35 is removed from the circuit when the operating frequency is between 283 and 400 kilocycles. This is accomplished by removing the upper link between capacitors C35 and C36.

The intermediate tracks are removed from the top cabinet section, and the blank panel provided is mounted over the space previously occupied by the load coil unit front panel. The tuning chart in the load coil control compartment should be removed and mounted on the black panel.

The charts in Figures 24A and 24B indicate the approximate setting of the coupling clip on the radio-frequency output transformer L10 for a 70-ohm reflected resistance in the tank circuit.

3.62 LOAD COIL UNIT HOUSING

The housing provided for the enclosure of the load coil unit when the transmitter is used with a remote antenna is equipped with a set of main tracks identical with those in the cabinet. With the intermediate tracks removed from the transmitter cabinet and inserted in the housing main tracks, the load coil unit can be installed or removed from this housing in the same manner as it was used in the cabinet.

The design of the housing is such that after proper matching adjustments have been made, the entire load coil unit may be installed and a gasketed front cover placed on the case to completely enclose it, thus offering protection from the weather. A limited number of these housings have been supplied to Central Depot. When needed, they should be requested from CAA Signals Division, Washington, D. C.

3.63 ADJUSTMENT OF REMOTE ANTENNA

3.631 GENERAL

With the load coil housing installed in its permanent position, intermediate tracks inserted, and the load coil unit chassis placed in position, the adjustments necessary for properly resonating the antenna may be performed. However, the coaxial cable is not brought into the housing and connected to the inside terminal board until the antenna is resonated, and line terminating adjustments completed. If the capacity of the antenna is known, the approximate tap on the load coil may be chosen according to the chart in Figure 26, and final tuning accomplished using an impedance measuring device. During the tuning adjustment, the transmitter must remain on to supply radio-frequency energy to the impedance box. The primary relay, K1, may be de-energized, or the PLATE key in the modulator control compartment placed in the ON position.

3.632 TUNING ANTENNA TO RESONANCE

The initial resonating of the antenna system is obtained by connecting the coaxial cable to the input terminals of a standard CAA impedance measuring box, temporarily connecting two insulated wires in series with the antenna between the ammeter and ground to the "unknown" terminals of the impedance measuring box, and tuning the load coil to resonance as would be indicated by maximum deflection of the impedance box galvanometer. Using the impedance measuring box, the procedure is as follows:

With the impedance box coupling control set at its mid-position, the known/unknown switch in the known position, insert 100 ohms in the decade and resonate the box by rotating the tuning capacitor. When the resonant condition is obtained as indicated by maximum deflection of the galvanometer, adjust the impedance box coupling control to provide ¾ deflection of the galvanometer, at the same time decreasing the protective decade resistance previously inserted to 1 ohm. Note the setting of the variable capacitor, and switch to the unknown position. If the antenna system is resonant any tuning of the ANTENNA LOAD coil dial will decrease the current indicated on the galvanometer. If, however, the system is not resonant, the ANTENNA LOAD coil dial should be adjusted to obtain maximum deflection of the galvanometer. Should the system not resonate within the tuning range of the ANTENNA LOAD coil dial, the load coil tap will have to be increased or decreased, dependent upon which side of resonance the system is detuned.

Whether an increase or decrease in inductance is required may be determined by resonant settings of the impedance box tuning capacitor when switching from the known to unknown position. After noting the setting of the variable capacitor as stated above, switch to the unknown and adjust the impedance box capacitor until a resonant condition is shown by maximum deflection of the galvanometer. If it is found that resonance occurs at a higher capacity setting when connected to the unknown position, the antenna system is capacitive and requires the addition of inductance for resonance. The addition of inductance is accomplished by increasing the setting of the ANTENNA LOAD coil dial for small steps and by means of an increase in taps for large steps. On the other hand, if a reduction of capacity is required when resonating the Z box in the unknown position, the antenna system is inductive and it is necessary to reduce the inductance by decreasing the setting of the ANTENNA LOAD coil dial for small steps and by means of a decrease in taps for large steps. This procedure should be repeated until the resonant point occurs at the same point on the capacitor tuning dial for both standard and unknown settings of the Z box.

3.633 MATCHING SECTION ADJUSTMENT FOR PROPER LINE TERMINATION

Following initial resonating of the antenna, the antenna ground lead is reconnected to the meter and the unknown terminals of the impedance box are connected to the terminal board inside the load coil housing. The clip lead connecting the terminal board to the matching section is positioned to terminate the line in its characteristic impedance of 70 ohms. If reactance is noted in addition to the resistive component, the antenna load dial must be retuned slightly to eliminate the reactive component. The approximate number of turns required in the matching section for various antenna resistances and capacitances can be determined from the chart in Figure 27. This chart is only approximate but should furnish an initial starting point from whence the final positioning of the clip may be determined by measurements made with the impedance measuring box for the proper line termination of 70 ohms.

Position the clip on the matching section as indicated on the chart. With the switch in the unknown position, adjust the input coupling control on the impedance box so that a value slightly above 50 is read when the box is resonated. Switch the box to known, resonate its tuning capacitor, and adjust the decade resistance to produce the same galvanometer deflection as found in the unknown position. If no reactance was noted in switching from unknown to standard, as would be indicated by the impedance measuring box tuning capacitor resonating at the same position, and a decade setting above 70 ohms was necessary to satisfy the same current conditions, the clip on the matching section must be adjusted to decrease the number of turns in the matching section; in the same manner, if reactance was not found, and the decade is less than 70 ohms, the clip should be adjusted to increase the number of turns in the matching section. The adjustments should be repeated until the matching section reflects a resistance of 70 ohms non-reactive. When this condition is satisfied, the transmitter may be turned off and the coaxial cable permanently connected to the terminal board inside the load coil housing.

3.634 ADJUSTING FOR PROPER PA LOADING

The coaxial line series capacitors C-35 and C-36 should be unplugged and the PLATE test key depressed while **the PA PLATE tuning is rechecked for no-load resonance.** Then the series line capacitors should be re-inserted into jacks EX and EZ in the upper transmitter cabinet compartment. The coupling tap on L-10 should then be varied in steps until the PA PLATE CUR. meter reads a maximum of 166 milli-amperes, which is the correct plate loading should full power operation of the transmitter be desired.

If the system has been properly tuned and terminated, no appreciable reactance will be noted in the PA. This may be observed by the setting of the PA PLATE tuning control when resonated for minimum plate current with no load, and when resonated with load. However, since the series line capacitors are designed to cover a comparative wide range in frequency, a small amount of reactance will be noted. The setting of the PA PLATE tuning obtained at resonance without load **should not be changed** when the antenna is resonated.

3.635 LOW-POWER OPERATION

Reduction of radio-frequency power output for the type TMO Transmitter is accomplished by reducing the number of coupling turns on the secondary of the radio-frequency transformer L-10. Thus, power output may be reduced to less than 5 watts of carrier power for all frequencies within the range.

3.7 AUDIO ADJUSTMENT

Nominal impedance of either 600 or 1200 ohms is provided by the primary of the audio input transformer T4. The transmitter is shipped with the primary connected to give a 1200-ohm impedance. A 600-ohm impedance is secured by moving the two shielded input leads from terminals 1 and 4 on transformer T4 to terminals 2 and 3. If operation is desired with a 1200-ohm impedance, the shielded leads should be left connected to terminals 1 and 4.

One-hundred-percent modulation of the carrier when operating at full power output can be obtained for audio input levels of between -27 and +4 decibels. A twenty-step attenuator in the audio input circuit allows adjustment of the audio gain. The scale behind the attenuator knob is marked in decibels attenuation. Full clockwise rotation gives zero attenuation. Each step in the counterclockwise direction inserts 1.5 decibels of attenuation up to and including the eighteenth step at which point 27 decibels of attenuation have been added. The nineteenth step gives 60 decibels total attenuation while the twentieth and last step gives infinite attenuation.

Maximum modulation of the carrier when operating at full-rated output will be obtained when the modulator plate current is approximately 180 milli-amperes.

Tone modulation of 1020 cps is obtained by closing PLATE test key in the modulator control compartment or deenergizing plate relay K1. Closing TONE test key or energizing tone relay K4 will provide tone modulation. Percentage modulation of tone frequency is controlled by the potentiometer R40 mounted on the underside of the modulator chassis and is accessible after the chassis has been withdrawn from the cabinet.

A cathode ray oscilloscope should be used to measure percentage modulation, the antenna circuit being coupled to the vertical deflection plates of the oscilloscope by means of a lead connected to one of the vertical deflection plates with the other end placed adjacent to the antenna lead.

3.8 SUMMARY OF ADJUSTMENT PROCEDURE

The following is a summary of the tuning and adjustment procedures for the type TMO transmitter:

1. Install crystal.
2. Set R. F. link switch S8 in proper position.
3. Place TUNE-OPERATE switch in TUNE position.
4. Turn on FILAMENT switch.
5. After filament warm-up, tune crystal stage to resonance.
6. Disengage load coil unit.
7. Depress PLATE key and tune PA tank to resonance.
8. Release PLATE key and set TUNE-OPERATE switch to OPERATE.
9. Re-check PA tank tuning.
10. Release PLATE key, adjust clip on L10 for approximately correct loading. See figures 24A and 24B. (166 ma is maximum permissible plate current for full rated output).
11. Engage load coil unit.
12. Tune antenna load coil to resonance.
13. Re-adjust coupling clip on L10, if necessary.
14. Check position of audio input transformer taps T4.
15. With the ATTENUATOR control set at infinity and both PLATE and TONE keys depressed, variable resistor R40 in the modulator unit should be adjusted until the MOD. PLATE CUR. is 165 milliamperes, which represents approximately 85 percent modulation for full rated power output. It is advisable to use an oscilloscope to examine the modulated carrier while adjusting variable resistor R40.
16. With external audio input, adjust position of the ATTENUATOR setting for 100% modulation. The audio-frequency input to transformer T4 should not exceed +4 DB in order to prevent excessive modulator plate current which will result in over-modulation and possibly the opening of the ¼-ampere 1000-volt fuse.

4. MAINTENANCE

4.01 GENERAL

Maintenance, inspection and service routines for TMO transmitters are herein described. Adherence to these routines should provide maximum performance from the equipment. This performance and uninterrupted operation, except for maintenance shutdown, will be assured by:

1. A thorough study of the equipment design and operation as described in this instruction manual by both maintenance and operating personnel.
2. Instructions to operating personnel to further insure their knowledge of the equipment operation.
3. A systematic and periodic application of suggested servicing routines.

Only by such means may an analysis be made to ascertain that the equipment is operating properly, and the most effective methods applied for inspection of components for deterioration, cleaning, checking tube emission, servicing relays and contactors, and for properly testing the electrical circuits.

4.02 MAINTENANCE RESPONSIBILITY

In view of the advanced technical design of this equipment, only personnel especially trained for such purposes should make adjustments or accomplish routine servicing. However, to properly care for the equipment during the absence of maintenance personnel, operating personnel should normally be capable of:

1. Detecting equipment irregularities.
2. Performing "minor trouble shooting" such as replacing tubes or fuses.

And, if within their capabilities during emergencies:

1. Performance of other phases of maintenance as may be authorized by instructions from the regional office.

4.03 INSPECTION SCHEDULES AND SERVICING ROUTINES

It is possible that this equipment will not be installed uniformly in the field, i.e., some installations will use this equipment in duplicate, others singly, and still others in conjunction with older emergency standby transmitters for either MHT or tower facilities. Routines based upon typical requirements of similar equipment should provide maximum performance and uninterrupted operation; these typical servicing and inspection routines are defined as follows:

a. Daily inspection for purpose of determining if optimum performance is being obtained.
b. A "minor" service that is accomplished following 360 hours of alternate operation with standby units. The frequency of application is monthly except at quarterly intervals when the following service is substituted.
c. A "routine" service that is accomplished following each 1000 hours of operation (approximate). The frequency of application of this service is dependent upon the type of equipment operation.
d. A "major" service routine covering items not necessitating as frequent servicing as found on above service routines.

4.04 SCOPE OF SERVICING ROUTINES

The daily inspection is as described principally for the purpose of site inspection and recording meter readings to determine that normal performance is being obtained.

The "minor" service, scheduled for:

1. TMO equipment operating alternately with standby units is thorough from the standpoint of inspection for loose connections, burned contacts, cleaning, determination of tube emission, and checking operating performances.

For equipment only operated 360 hours monthly there is little reason for burnishing each relay contact, individually checking each tube and tightening each connection. The excess dust accumulation may be blown out, contacts visually inspected, tube emission judged by a careful analysis of existing currents and voltages, and the percentage of modulation and tone oscillator frequency observed on an oscilloscope. The performance of this equipment when properly installed, periodically serviced and adjusted as directed, should not change appreciably during the 360-hour operating period.

The "routine" service, scheduled for:

1. TMO transmitters operating without standby units or alongside older "emergency standby" transmitters used only at infrequent intervals for testing.
2. TMO transmitters operating alternately with standby units,

is suggested monthly for the former type of operation and at 90 day intervals for the latter at which time it is substituted for the "minor" servicing routine. The service is complete with all units thoroughly serviced, all contacts burnished properly, all connections checked, all chassis and insulators cleaned, all receiving types of tubes checked with a tube tester, all transmitting tubes tested by substitution in their circuits, and the various electrical functions checked with instruments.

The "major" service, scheduled for TMO transmitters is termed as such since certain items not requiring as frequent a service or adjustment are included with a routine servicing. This would include principally service to the ventilating fan; however, items such as tuning the antenna system, making audio runs, line equalization, etc., when performed as directed, would also be termed a "major" service.

4.1 ROUTINE MAINTENANCE AND INSPECTION

4.12 DAILY INSPECTION

a. Record all meter readings, both with and without modulation.

b. Comparison of meter readings may be used for determination of reduced tube emission and relative performance of the equipment.

c. Any tube showing signs of failure should be immediately replaced.
NOTE: An abnormal decrease in normal plate current of several milliamperes may indicate a line voltage change.

d. Monitor transmission, especially noting any sign of carrier hum or voice distortion.

4.13 WEEKLY INSPECTION

a. Weekly inspection consists of same items as above with exception that the quality of transmission should be monitored remotely by maintenance personnel.

4.14 "MINOR" SERVICING OF TMO TRANSMITTERS

A typical servicing routine suggested for those installations in which alternate standby operation is possible as described in section 4.03 paragraph "b". For continuous operation this routine would not apply.

(1) General Preparation for Servicing

To obtain full benefit from any type of servicing that is planned, the operation and performance of the equipment should be discussed with operating personnel. If irregularities have been noted, these should be corrected at the time of service. Checking the daily form of meter readings may suggest the location of trouble, but should this fail, a check of possible troubles, etc., as listed in Section 4.2 may prove helpful. A set of existing meter readings should be recorded for reference purposes when returning the equipment to normal operation and/or for determination of improved performance.

NOTE: Zero setting of meters should be noted and corrected. (Refer to Section 3.12 paragraph 3).

(2) Shutting the Transmitters Down

Immediately after shutting the transmitter down for service, all components should be inspected for signs of overheating or overloading, such as indicated by wax leaking from capacitors, charring of resistors, etc.

NOTE: Discharge all high voltage capacitors to prevent accidental shock.

(3) Check Tube Emission by

a. Analysis of existing meter currents.

1. Observe all currents both with and without tone modulation.

   NOTE: Although tone modulation is not normally utilized at control towers, it may be used for determining operation of transmitter under constant modulated conditions.

2. If irregularities are suspected in circuits where meters are not located, measure operating voltages. (Refer to Section 4.3).

b. Use tube tester if operating condition is not apparent, such as for stages not equipped with meters.

(4) **Cleaning**

a. Withdraw each chassis from the cabinet and blow out dust accumulations. Points of high potential normally collect more dust and should be thoroughly cleaned of dust and any corrosive effect. (Check transmitter pedestal security to assure that cabinet does not tip forward upon withdrawing chassis).

b. Remove all dust from the inside of the cabinet.

c. Clean exhaust and inlet screen openings using soft brush.

d. Clean filter unit by removing and tapping it lightly on piece of paper placed on the floor.

(5) **Connections**

a. Carefully check all connections and tighten as necessary.

b. **Fuses, Check for:**

   1. Proper value.
   2. Contact pressure.
   3. Excessive temperature (indicative of poor contact).

(6) **Relays**

a. Inspect contacts and burnish if necessary.

b. Inspect for binds by operating armatures by hand.

c. Check armature and contact spring tensions.

(7) **Ventilating Fans**

a. Inspect blower wheel for alignment and shock mounts for resiliency.

b. Service in accordance with 4.17.

(8) **Crystal**

a. If spare crystal is available, change crystal installing spare.

(9) **Exterior Cabinet Cleaning**

a. Replace all chassis in cabinet.

b. Clean cabinet exterior using soft cloth or dry rubber sponge.

(10) **Antenna**

a. Examine antenna for loose connections and cracked insulators.

b. Tighten antenna flat top and guys as necessary to remove sag.

c. Clean and inspect lead-in bowl.

(11) **Tuning and Adjustment**

a. Retune, insuring that connections have not become dislodged while servicing. Note if dial settings of controls are normal.

   NOTE: Tuning procedure summary found in Section 3.8.

b. Check percentage of modulation using an oscilloscope.
   NOTE: A slight decrease of emission of modulator or speech tubes causing reduced percentage of modulation will necessitate advancing the transmitter gain control slightly to provide approximately 95% modulation; however, do not assume that emission of modulator or speech has decreased without first observing the output of the regulated speech amplifier to determine that normal input voltage is being supplied from the speech amplifier.

(12) **Returning Transmitter to Normal Operation**

a. Advise operating personnel that No. .... transmitter is to be returned to operation following service.

b. Observe all currents, comparing with initial reference values recorded.

c. Request a short test broadcast for purpose of observing transmitter operation and quality of transmission.

d. Record complete set of meter readings.

(13) **Termination of Servicing**

a. Record servicing date in station maintenance log.

4.15 "ROUTINE" SERVICING OF TMO TRANSMITTERS

A typical "routine" servicing procedure suggested for installations operating as described in Section 4.03, paragraph c, follows. This routine is substituted for the "minor" service procedure at 90 day intervals if equipment is alternately operating, and accomplished monthly where equipment operates continuously.

(1) **General Preparation for Servicing**

As described in Section 4.14, paragraph 1.

(2) **Shutting the Transmitter Down**

Immediately after shutting the transmitter down for service, all components should be inspected for signs of overheating or overloading, such as indicated by wax leaking from capacitors, charring of resistors, etc.

(3) **Checking Tube Emission**

a. After every 1000 hours of service, test all tubes. Check receiving types in a tube tester and where possible check transmitting types individually by substitution.

NOTE: Spare crystal oscillator tubes of the type 6V6G should be tested for proper operation in the crystal stage and tagged for future use.

b. Record any tube data changes in station maintenance log.

c. Revise tabulated list of tubes installed and check balance against the tabulated list if changes have been made.

NOTE: This enables operating personnel or maintenance personnel, as the case may be, to properly keep tube records current and prevents accidental interchanging of similar tubes in other sockets.

(4) **Cleaning**

a. Remove each chassis from the cabinet and thoroughly clean using brushes to loosen excessive dust accumulations, followed by bellows (or vacuum cleaner if available) and customary dust cloth. (Check transmitter pedestal to assure that cabinet does not tip forward upon withdrawing chassis).

b. Clean all ceramic insulators using a dry cloth, if excessively dirty, by wiping with a cloth that has been dipped in carbon tetrachloride (ctc).

c. Clean under surfaces of chassis above transmitting tubes.

d. Clean exhaust and inlet screen openings using a soft brush.

e. Remove all dust from the inside of the cabinet.

f. Clean filter unit by removing and tapping it lightly on piece of paper placed on the floor. If this unit chokes up quite frequently, its replacement is necessary to maintain adequate ventilation to the transmitter.

(5) **Connections**

a. Make a thorough check to insure that all connections and mounting screws are secure on all resistors, sockets, coils, capacitors, terminal board, and transformers. Inspect for cracked insulators.

b. Carefully examine Jones plug slip connections for security. Any discoloration of a prong resulting from excessive heating is an indication of poor contact.

(6) **Fuses, Clips and Ferrules**

a. Check fuse clips for contact pressure as noted when removed and replaced. Polish contact surfaces as required so that a low resistance contact will be insured.

b. Inspect security ferrule screws on renewable type fuse.

c. Check fuses for proper capacity.

(7) **Relays**

NOTE: All cleaning should be completed before servicing of relays.

a. Inspect contacts, clean and burnish if necessary.

NOTE: Burnishing operations should be limited to use of crocus cloth on heavy contacts and a fine burnishing tool on light contacts. This prevents excessive and unnecessary contact wear. Contacts burned excessively should be replaced. In cleaning contacts, use only CTC (USP).

b. Inspect mechanical assembly of relays. Check and tighten all connections. Check armature bearing surfaces and pinions to insure freedom from binds, repositioning if necessary.

c. Check armature and contact spring tensions.

(8) **Sockets**

a. Inspect all tube sockets. Contact tension is indicated by a secure fit when tube is inserted in socket. Clean socket contacts, using CTC, burnishing if corroded or otherwise soiled.

NOTE: Pay particular attention to the type 866A mercury vapor type socket. This type tube draws considerable filament current and requires close adherence to specified filament voltages to insure normal tube life.

(9) **Z Track Slide Assembly and Other Points of Friction**

a. Inspect assemblies for freedom of movement. Apply a very thin coat of white vaseline to track to insure a minimum of wear. Grease track ball bearings.

b. Annually apply a minute amount of light oil on door hinges, brackets, and latches, wiping off excess which does not flow in. Also apply light coat of white vaseline to threads of captive screws on front panels.

(10) **Ventilating Fan**

a. Wipe up excess oil leakage.

b. Add two drops of oil to bearings.

c. Check thermostat.

(11) **Crystal**

a. If spare crystal available, change crystals.

(12) **Exterior Cabinet Cleaning**

a. Clean cabinet exterior.

b. Polish meter windows.

(13) **Adjustments**

A. Tuning. Make a careful check of all circuits to assure that connections, etc,. were not disturbed during the servicing. Check dial settings of all controls. If appreciable deviation is noted, determine cause. All currents must be checked and/or adjusted for proper operating values as determined by the type of facility operation.

1. Crystal oscillator: Refer to Section 3.2 and 4.213.
2. Power amplifier: Refer to Section 3.3.
3. Antenna load coil.
    a. Local: Refer to Section 3.5.
    b. Remote: Refer to Section 3.6.

NOTE: Semiannually, check tuning as described in Sections 3.632 and 3.633.

B. Audio. Check and adjust speech circuits for proper percentages of modulation using an oscilloscope.

1. Tone oscillator frequency (MHT facilities). Check, using an oscilloscope, and checking 1020 cycles as the 17th harmonic of 60 cps.

(14) Returning transmitter to normal operation.

a. Refer to Section 4.14, paragraph (12).

(15) **Termination of Servicing**

a. Refer to Section 4.14, paragraph (13).

4.16 "MAJOR" SERVICING OF TMO TRANSMITTERS

At periodic intervals as noted below, certain phases of maintenance are included with the "routine" transmitter servicing procedure which results in maintenance of a major nature. These additional routines are listed below:

1. **Transmitter:**
   a. Service in accordance with Section 4.15.
2. **Fan and Blower:**
   a. Service in accordance with Section 4.17 every 5000 hours of operation.
3. **Adjustments:**
   a. **Tuning**
      1. Transmitter tuning adjustments in accordance with Section 3.

   b. **Antenna**
      1. Semiannually check tuning of remote antenna as described in Section 3.63.

   c. **Equalization of Overall Audio Response.** Semiannually an overall audio frequency characteristic of the transmitter should be determined and correction made to the CA-596 equalizer if necessary. The procedure is as follows:
      1. Transmitter audio input impedance must be 600 ohms to properly match equalizer.

      NOTE: At certain facilities where two 1200-ohm input circuits are operating in parallel, no changes will be necessary. At other facilities it may be necessary to isolate the undesired input circuit.

      2. Capacitively couple a cathode ray oscilloscope to the antenna. This may be accomplished by bringing a pick-up wire from the antenna to the vertical plates of the oscilloscope. Where local antennas are used, an insulated wire may be wrapped around the antenna lead-in to provide sufficient coupling for adequate deflection.
      3. Remove the equalizer from the circuit by connecting a jumper between the outside terminals on the attenuator pad and unsoldering the grey-colored lead from center terminal of the attenuator pad.
      4. Remove the limiter tube from the regulated output amplifier.
      5. Determine the percentage of modulation that may be used for the overall audio run without overloading modulator tubes on the higher audio frequencies. The procedure is as follows:
         a. Maintaining a constant input level of -50 db into the regulated-output amplifier from an audio oscillator, adjust the transmitter control **for 90-percent modulation at 100 cps.**

      NOTE: Output of audio oscillator is matched to input impedance of the regulated output amplifier using a standard audio-frequency attenuator with an AC voltmeter connected to maintain constant attenuator input voltage.

         b. **Reset the audio oscillator to 4000 cps.** Maintaining the same audio attenuator input level, record the **resulting percentage of modulation.** This modulation percentage will be used for the overall run.
      6. Determine the overall audio attenuation characteristics and the degree of equalization necessary to flatten the response.
         a. With the audio oscillator adjusted to feed -50 db into the regulated-output amplifier at 100 cps, adjust the amplifier attenuator to -6 db output.
         b. Adjust the transmitter attenuator **to obtain the same degree of modulation as obtained in (5b) above.**
         c. **Record** the transmitter attenuator setting.

d. Maintaining the -50 db level into the regulated-output amplifier, **reset** the audio oscillator **first to 1000 cps, and then to 4000 cps,** adjusting and recording the transmitter control setting which result in the **same percentage** of modulation as obtained in (5b) above.

e. Compute the audio loss between **100 and 4000 cps** by taking the difference of the transmitter attenuator setting at these two frequencies; likewise, in the same manner determine the loss between **1000 and 4000 cps.**

f. These two computations will indicate the amount of attenuation necessary at 100 and 1000 cps to approximately flatten the overall characteristics. The value for their respective frequencies may be located on the equalization chart and the setting of the equalizer determined.

7. Connect the equalizer into the circuit and determine the effectiveness of the degree of equalization as a result of the above adjustment.

a. This is accomplished by maintaining -50 db level into the microphone amplifier and recording the resultant percentage of modulation as the frequency of the audio oscillator is set to 100, 200, 400, 600, 1000, 1500, 2000, 3000, and 4000 cps. For the initial reference level of modulation, adjust the transmitter control to produce the same percentage of modulation obtained at 4000 cps in the previous test (5b).

b. The resultant overall percentage of modulation should remain fairly constant; however, some variation is inevitable as the equalizer characteristics do not exactly complement the sideband cutting.

c. If the variation in response can be reduced as judged by inspection of the equalizer calibration curves, the pad may be moved a step and a test made to determine if improvement results.

d. **Final Percentage Modulation and Limiter Tube Adjustment.** Following equalization above and with the limiter tube still removed from the regulated amplifier, feed 400 cycles at a level of -50 db into the microphone amplifier.

1. Adjust the regulated amplifier to produce a plus 1.5 db level into the transmitter.
2. Adjust the transmitter attenuator control to obtain 100 percent modulation.
3. Insert the limiter tube.

NOTE: This should reduce the regulated output level to 0.0 db ±0.5 db and result in an average modulation percentage of approximately 85%.

4.17 BLOWER MOTOR OVERHAUL

4.171 GENERAL ELECTRIC TYPE KSC

1. Remove motor assembly from blower wheel housing by loosening four mounting screws.
2. Loosen the set screw through the blower wheel shaft bushing with a 1/8″ Allen wrench and remove blower wheel.
3. Remove rear end bell by loosening and removing end bearing frame assembly screws.
4. Lift out armature and clean shaft with carbon tetrachloride.
5. Blow out all passages with air.
6. After thorough cleaning of all parts, replace armature, end bell, and attach blower wheel to shaft, bearing in mind that parts should not be forced together.

SPEED MEMO

SUBJECT

Instruction Book for TMO Transmitter

TO:

Transportation Officer
Presidio of San Francisco
For: Consolidated Property Officer
San FRancisco, California

DATE OF INITIAL MESSAGE
8/25/66

SIGNATURE OF ORIGINATOR
E. W. Calkins

TITLE	ROUTING SYM.
Chief, AFS 28670	

INITIAL MESSAGE

We delivered a TMO Transmitter to you on 12/17/66. The enclosed instruction book should have been included with the transmitter shipment.

Please send the book to the unit using the transmitter.

REPLY MESSAGE

FROM:

CHIEF, AIRWAY FACILITIES SECTOR
FEDERAL AVIATION AGENCY
P. O. BOX 6005
SANTA ROSA, CALIFORNIA 95406

DATE OF REPLY

SIGNATURE OF REPLIER

TITLE	ROUTING SYM.

FAA FORM 2800-1 (10-64) USE PREVIOUS EDITION (1360)

7. Adjust end thrust by loosening hex nut with a 7/16″ end wrench and reset thrust for 1/32″ clearance. After proper clearance the hex nut should be tightened.
8. Lubricate the motor with oil equivalent to Gargoyle DTE, heavy medium, manufactured by Socony Vacuum Oil Company, N. Y.
9. After lubrication the blower wheel **must rotate freely** and if there is excessive friction on the self-aligning bearings, the end bell should be tapped with a light mallet.
10. The motor should now be attached to the blower mounting and made ready for operation.

4.172 A. G. REDMOND CO. TYPE R MODEL 123 (See Figure 22)

1. Remove motor assembly from blower wheel housing by loosening four mounting screws.
2. Loosen the set screw through the blower wheel shaft bushing with a ⅛ in. Allen wrench and remove blower wheel.
3. Remove motor by removing four shock mount screws.
4. Remove motor ventilator shell (2) by removing four screws (1); then tapping evenly around edge of ventilator shell with mallet. The ventilator shell is a press fit.
5. Carefully remove cooling fan (3) by prying with screw-driver as close to shaft as possible so as not to distort it.
6. Remove four case bolt nuts (4).
7. Disassemble motor cases (5) by using screw-driver and mallet Each case has two ribs (6) between cooling fins, located 180 deg. apart. Rest screw-driver against these ribs and pound evenly with mallet. These cast cases are a tight press fit. Do not pound on edge of case (7) as care should be taken not to burr edges.
8. Separate cases (5), rotor (8), and stator (9). Clean all parts with air.
9. After cleaning replace lead end case (5 front) on stator (9). Line up case mounting holes with case bolts (10) and tap evenly with a mallet until in position.
10. Place few drops of oil (SAE No. 20) on both bearing journals of rotor (8). Reassemble rotor (8) in lead end case (5 front).
11. Replace rear case (5 rear). Line up cooling fins and tap evenly with mallet until in position.
12. Reassemble four case bolt nuts (4). Tighten with screw-driver.
13. With small, stiff wire push back oil slinger (11) in each case, on motor shaft so part will not rub when shaft is turned.
14. Reassemble cooling fan (3).
15. Replace ventilator shell (2) by tapping evenly with mallet until in position.
16. Assemble four screws (1).
17. Before assembling oil tube plugs (12), oil motor with any good grade SAE No. 20 oil as specified on nameplate.
18. Rotor should now **rotate freely.** If not, tap motor case lightly with mallet while motor is running to position self-aligning bearings. Do not strike shaft.
19. Reassemble motor, attach to blower mounting, and make ready for operation.

4.2 REPAIR

4.21 POSSIBLE TROUBLES AND REMEDIES

4.211 GENERAL

Improper operation of the type TMO transmitter will generally be due either to maladjustment of controls or breakdown of a component. The most frequent cause of trouble in transmitting equipment is tube failure. Routine recording of meter readings should make it possible to anticipate tube failure. If the equipment becomes inoperative, a check of all fuses should be made immediately. If an open fuse is found, replace it with a fuse of the **same rating.** However, the circuit supplied from this fuse should be checked for possible trouble before reapplication of power. If the fuse opens again, it is a good indication that a permanent fault exists, and a careful check should be made of circuit components.

Utilization of data in Section 4.3 covering typical voltage and currents of vacuum tubes, resistors, capacitors and relays, will aid in determining the circuit in which trouble might be present.

4.212 FUSES

The following list groups the possible trouble by circuits which are supplied through fuses:

F1 or F2 Opening of these input fuses indicates a short-circuit between a-c input lines between this fuse board and contactors K2 and K3 or fuses F4 and F5. Failure of F2 indicates a possible ground of this circuit. If these fuses open after K3 is closed, a short-circuit or ground on the line between this contactor and fuse F3, F6, indicator light I1, Transformer T8, contactor K5, transformer T3, or solenoid of K2 is indicated.

F3 If fuse F3 is open, probable trouble in the blower or thermostat switch circuit is indicated. If this circuit is tested in an ambient temperature below 20 degrees Centigrade, the thermostat switch will be normally open.

F4 Failure of fuse F4 suggests either trouble with the LOW-NORMAL TEMPERATURE link switch or a short-circuit condition existing in either the primary or secondary circuit of the rectifier filament transformer T1, which, in turn, would be caused by short-circuits at the sockets of rectifier tubes V1 or V2 or trouble in the tubes themselves.

F5 Opening of fuse F5 in the primary of plate transformer T2 indicates trouble in the high-voltage power supply. A ground in smoothing filter reactor L1 or short-circuit of filter capacitors C1 or C2 or bleeder resistor R1 will cause F5 to open. Grounding of the high-voltage direct current circuit in the modulator, buffer or power amplifier plate or screen circuits will also open F5.

F6 Failure of fuse F6 suggests a short-circuit condition in primary or secondary of filament transformer T7 in the modulator or at the tube sockets supplied by this transformer.

F7 If fuse F7 is open, probable trouble in the low-voltage plate transformer T3 is indicated, such as a grounded smoothing filter reactor L2, or short-circuited filter capacitor C6 or C7 or bleeder resistor R16.

F8 Opening of fuse F8 in the plate circuit of modulator tubes V6 or V7 indicates a failure of capacitor C16 or short-circuits on resistor R12 and R13 or meter M1 or a loss of negative bias on the control grids of these tubes.

F9 Failure of fuse F9 suggests a short-circuit in filament power transformer T8 which supplies filament power to tubes in the radio-frequency unit.

4.213 RADIO-FREQUENCY SECTION

Possible troubles in the radio-frequency unit are grouped as follows:

CRYSTAL OSCILLATOR

Excessive plate current indicated by the oscillator plate current meter suggests a short-circuit to ground in the plate circuit. The plate tuning capacitor should be examined for bent plates or foreign material between plates. Failure of plate bypass capacitor C22 will cause a high current to flow through the oscillator plate current meter.

Low plate current suggests loss of screen voltage on the oscillator tube or a loss of plate voltage. Loss of screen voltage can be due to failure of screen bypass capacitor C19 or opening of screen resistor R18.

A defective crystal is usually indicated by either no dip in plate current at the resonant point of the plate tuning capacitor or a very shallow dip. The defective crystal should be replaced by the spare unit, and the faulty unit returned to the contractor for repair or replacement according to instructions governing replacement of parts. **Adjustment of the top electrode of the crystal should never be made** since this will result in a variation of frequency as well as stability of the crystal. The seal on the crystal unit should never be broken without permission from the contractor while the guarantee is in force.

Loss of plate voltage suggests an open circuit in the oscillator plate coil or meter M2 or trouble in the low-voltage power supply in the modulator unit.

BUFFER AMPLIFIER

Excessive plate current in the buffer stage measured at R29 suggests a short-circuited plate bypass capacitor C29, a short-circuit to ground of the plate tank inductance L6 or an excessive screen voltage which in turn might be caused by an open circuit in the screen bleeder resistor R30. Abnormal plate current might be caused by the simultaneous failure of the bias supply and loss of radio-frequency excitation at the grid of the buffer.

Low plate current might be caused by a loss of radio-frequency voltage on the buffer control grid due to failure of the coupling capacitor C24. Loss of screen voltage because of failure of screen bypass capacitor C26 or the opening of screen dropping resistor R23 would also result in a low plate current.

Loss of plate voltage suggests an open circuit in the tank inductance L6 or plate dropping resistor R29 or a partial short-circuit in the plate bypass capacitor C29.

Failure of tank capacitor C27 would destroy the resonant condition of the tank circuit which would remove radio-frequency excitation from the power-amplifier tubes.

Failure of tank shunting resistor R25 would result in excessive excitation of the power amplifier stage, especially if the operating frequency is near 283 kilocycles, the resonant frequency of the buffer plate tank circuit.

POWER AMPLIFIER

Excessive plate current suggests an overloaded output circuit, short-circuit of tank capacitor or tank inductance causing loss of resonance, simultaneous loss of bias and radio-frequency excitation, abnormal screen voltage due to short-circuit of screen dropping resistor R27, short-circuit to ground of plate bypass capacitor C31 or tank inductance L8 or L9, or link switch S8 in wrong position. Abnormal plate current will result when the plate tank is tuned to resonance with the output circuit open if the clip which connects to the output winding of the tank circuit makes contact with the turn adjacent to the one to which it is attached.

Low plate current might be caused by loss of excitation, loss of screen voltage due to opening of screen dropping resistor R27, failure of screen bypass capacitor C30, opening of parasitic resistor R31 or insufficient loading of the output circuit which in turn might be caused by an open antenna contactor, K5, load coil, L11, or ammeter, M4.

Loss of plate voltage may be caused by an open circuit in the plate tank inductances L8 or L9, parasitic resistor R31, or meter M3.

4.214 CAPACITORS AND RESISTORS

A capacitor that is short-circuited permanently can be detected since it will give a low resistance reading on an ohmmeter. Capacitors that have intermittent break-down features can usually be detected with the use of a megger which measures the resistance of the component under high voltage stress.

Resistors may be measured with an ohmmeter; however, one end of the resistor should be disconnected from the circuit to eliminate any possible shunting effects of adjacent circuits. Voltages and currents associated with each resistor and capacitor are tabulated under Typical Operating Test Data sections, 4.32 and 4.33 respectively.

4.215 INDUCTORS, TRANSFORMERS AND REACTORS

Defective radio-frequency inductances can usually be detected by visual inspection. Extreme care should be used in the handling of the antenna load coil, since the wire comprising the load coil stator and rotor is a litz type comprising 41 strands of number 36 enamel wire and all forty-one strands of litz cable must be in the circuit to maintain the coil's high efficiency.

Power transformers may be checked by measuring the voltages appearing across the secondary with an a-c voltmeter. Care must be taken in measuring voltages across the high-voltage plate transformer T2.

Filter reactors may be measured by an ohmmeter or a megger in the case of an intermittent short-circuit to case. If a high hum level is observed on the carrier, it is probably indicative of a partial short-circuit in the smoothing filter reactor provided the filter capacitors have been previously checked. Ripple at the filter output can be measured by means of an a-c voltmeter connected across the high-voltage filter output and isolated from it by means of a series capacitor of at least one microfarad capacity and a voltage rating of at least 600 volts working. If the ripple voltage read on the a-c meter is more than one percent of the direct current voltage, which is about 280 volts for the low-voltage power supply and about 490 volts for the high-voltage power supply, a faulty smoothing filter reactor or capacitor is indicated.

4.216 AUDIO SECTION

Loss of audio amplification generally results from faulty tubes or open or short-circuited components in the audio amplifier. Voltages should be measured at the tube sockets of each of the audio tubes and readings compared with those given in section 4.31. Plate and screen voltages on the audio amplifier tube 6SJ7 should be measured with a 20,000-ohm-per-volt voltmeter, or erroneous readings will result, especially in the case of screen voltage measurement. Loss of voltage on the plate of the 6V6G driver stage could be caused by opening of inductance L3 or primary of transformer T5. Abnormally high static modulator plate current, over 105 ma., is evidence of either total or partial loss of grid bias. This loss of bias could be due to rectifier tube V3, or short-circuit of resistors R7, or R17, capacitors C8 or C15.

4.217 RELAYS

Plate and filament contactors K2 and K3 and antenna contactor K5 will pull in at 95 volts when operating normally.

Twelve milliamperes is the normal operating current for the primary and tone relays K1 and K4.

Failure of a contactor or relay may be due to a defective solenoid. Correct resistance values of solenoids are listed under section 4.34. Bent contact assembly arms, worn or dirty contact points may prevent the relay or contactor from closing properly.

4.3 TYPICAL OPERATING DATA

FULL CARRIER POWER, NO MODULATION

4.31 TYPICAL VOLTAGES AND CURRENTS VACUUM TUBES

TYPICAL VOLTAGE READINGS

Tube Symbol	Tube Type	Function	Cathode	Control Grid	Screen	Plate
V8	6V6G	Crystal Osc.	4.6	—	105	255
V9	6V6G	Buffer	0	–24	135	215
V10	807	Power Amp.	0	–57	240	475
V11	807	Power Amp.	0	–57	240	475
V4	6SJ7	Audio Amp.	2.0	0	50	180
V5	6V6G	Audio Driver	16.0	0	255	255
V6	807	Modulator	0	–24	290	490
V7	807	Modulator	0	–24	290	490
V1	866A	Rectifier	—	—	—	600 AC
V2	866A	Rectifier	—	—	—	600 AC
V3	5Z3	Rectifier	—	—	—	480 AC

TYPICAL CURRENT READINGS (Milliamperes D. C.)

V8	6V6G	Crystal Osc.		—	1.8	5.10
V9	6V6G	Buffer		0.9	2.75	27.00
V10, V11	807	Power Amp.		7 both	21.0	166.00
V4	6SJ7	Audio Amp.		—	0.09	0.34
V5	6V6G	Audio Driver		—	—	24.00
V6, V7	807	Modulator		— both	4.0	90.00
V1, V2	866A	Rectifier		—	—	385.00
V3	5Z3	Rectifier		—	—	50.00

4.32 RESISTOR VOLTAGES AND DISSIPATION

Symbol	Rated Resistance (ohms)	Resistor Voltage	Power Dissipation (watts)	Rated Power
R1	15,000	483	15.5	30
R3	4,800	2.0	0.0008	2
R4	2.5 Meg.	225	0.02	2
R5	270,000	90	0.031	2
R6	33,000	14	0.006	2
R7	600	34	1.95	4.8
R8	390,000	—	—	2
R9	160,000	—	—	2
R10	650	17	0.450	12
R11	150,000	—	—	2
R12	9,600	287	8.6	20
R13	6,000	200	6.7	16
R14	186,000	—	—	2
R15	2,800	—	—	2
R16	20,500	285	3.9	18
R17	400	23	1.32	4.8
R18	100,000	200	0.40	2
R19	7,500	134	0.24	10
R20	100,000	7.5	—	2
R21	20,000	18	0.016	2
R22	400	4.6	0.053	4.8
R23	6,800	80	0.94	10
R24	5,000	41	0.34	2
R25	7,500	73	0.71	2
R27	11,500	244	5.2	14
R29	7,000	265	10	20
R30	15,000	126	1.1	16
R31	10	0.83	0.069	4.8

4.33 MICA AND PAPER CAPACITORS, OPERATING VOLTAGES—(Unmodulated)

Symbol	DC Voltage	Peak AC Voltage	Net Peak Voltage
C1	483	2	485
C2	483	2	485
C3	2	—	2
C4	37	—	37
C5	257	—	257
C6	375	30	405
C7	280	—	280
C8	57	—	57
C10	16	—	16
C11	160	11	171
C12	16	11	27
C13	—	—	—
C14	266	42	308 S/N 1-168
C14	—	25	25 Above S/N 168
C15	24	—	24
C16	286	—	286
C18	5	34	39
C19	105	77	182
C21	0	0	0
C22	248	5	253
C24	278	212	490
C26	134	77	211
C27	0	230	230
C28	110	5	115
C29	216	4	220
C30	230	114 Modulated	344
C31	461	226	687
C32	0	460 Unmodulated	460
		920 Modulated	920
C33	0	460 Unmodulated	460
		920 Modulated	920
C34	0	0	0

4.34 RELAY OPERATE AND RELEASE VOLTAGES AND CURRENTS, AND SOLENOID DC RESISTANCE

	Voltage		Current-Amp.		Solenoid
	Operate	Release	Operate	Release	DC Resistance
K1	1.5	0.4 DC	0.007	0.002 DC	300
K2	85	65 AC	0.062	0.038 AC	260
K3	85	65 AC	0.062	0.038 AC	260
K4	1.6	0.8 DC	0.007	0.004 DC	300
K5	90	83 AC	0.056	0.035 AC	540

5. PARTS LIST

5.1 CAPACITORS

Symbol	Function	Capacity Mfd.	Working Voltage	Case Material	Case Type	Mfr. Type No.	Mfr.
C1 *	H. V. Filter	10	600		Impreg. Paper Diel. Fab. Met. Case	26F105	GE
C2 *	H. V. Filter	10	600		Impreg. Paper Diel. Fab. Met. Case	26F105	GE
C3 *	Audio Amp. Cathode Bypass	5	100		Impreg. Paper Diel. Drawn Met. Case	XDRHW1-5	SR
C4 *	Audio Amp. Screen Bypass	2	400		Impreg. Paper Diel. Drawn Met. Case	XDRHW4-2	SR
C5 *	Audio Amp. Plate Bypass	0.5	600		Impreg. Paper Diel. Drawn Met. Case	XDRMW6-0.5	SR
C6 *	L. V. Filter	1.0	600		Impreg. Paper Diel. Drawn Met. Case	XDRCW6-1	SR
C7 *	L. V. Filter	10	600		Impreg. Paper Diel. Fab. Met. Case	26F105	GE
C8 *	Bias Filter	5	100		Impreg. Paper Diel. Drawn Met. Case	XDRHW1-5	SR
C10	Audio Driver Plate	0.007 ± 5 %	600	BM262	Mica Diel.	BEL-10	SO
C11 *	Audio Amp. Plate Coupling	0.05	600		Impreg. Paper Diel. Drawn Met. Case	XDRMW6-.05	SR
C12 *	Audio Driver Cathode Bypass	5	100		Impreg. Paper Diel. Drawn Met. Case	XDRHW1-5	SR
C13	Tone Feed Back	.0035 ± 5%	600	BM262	Mica Diel.	BEL-10	SO
C14	Audio Driver Plate	.01	600	BM262	Mica Diel.	BEL-10	SO
C15 *	Bias Filter	5	100		Impreg. Paper Diel. Drawn Met. Case	XDRHW1-5	SR
C16 *	Mod. Screen Bypass	2	600		Impreg. Paper Diel. Drawn Met. Case	XDRCW6-2	SR
C18	Osc. Cath. Bypass	.03	600	BM262	Mica Diel.	HL-10	SO
C19	Osc. Screen Bypass	.01	1200	BM262	Mica Diel.	HL-25	SO
C20	Osc. Plate Tuning	12-325 mmfd. Midline Frequency			Variable Air	MC-910	BD
C21	Osc. Plate Meter Bypass	.001	600	BM262	Mica Diel.	HL-10	SO
C22	Osc. Plate Bypass	.01	1200	BM262	Mica Diel.	HL-25	SO
C24	Buffer Grid Coupling	.000025	1200	BM262	Mica Diel.	HL-25	SO

5.1 CAPACITORS—Continued

Symbol	Function	Capacity Mfd.	Working Voltage	Case Material	Case Type	Mfr. Type No.	Mfr.
C26	Buffer Screen Bypass	.01	1200	BM262	Mica Diel.	HL-25	SO
C27	Buffer Plate Tuning	.0001	1200	BM262	Mica Diel.	HL-25	SO
C28	PA Grid Bypass	.01	600	BM262	Mica Diel.	HL-10	SO
C29	Buffer Plate Bypass	.01	1200	BM262	Mica Diel.	HL-25	SO
C30	PA Screen Bypass	.002	2500	BM262	Mica Diel.	HL-50	SO
C31	PA Plate Bypass	.004	2500	BM262	Mica Diel.	HL-50	SO
C32	PA Plate Tuning	.002 ± 2%	3000	BM262	Mica Diel.	F2L-322	SO
C33	PA Plate Tuning	.002 ± 2%	3000	BM262	Mica Diel.	F2L-322	SO
C34	PA Plate Meter Bypass	.005	600	BM262	Mica Diel.	HL-10	SO
C35	Ant. Series Tuning	.01	600	BM262	Mica Diel.	A2-1110	SO
C36	Ant. Series Tuning	.005	600	BM262	Mica Diel.	A2-1250	SO

5.2 FUSES

Symbol	Function	Amp. Cur. Rating	Volt Rating	Length	Ferrule Diam.	Type	Mfr.
F1	Line	6	250	2	9/16	1006	BN
F2	Line	6	250	2	9/16	1006	BN
F3	Blower - S/N 1-168	¾ Slo-Blo	250	1¼	¼	1267	LF
F3	Blower - Above S/N 168	1 Slo-Blo	250	1¼	¼	1268	LF
F4	Rect. Filament	1	250	1¼	¼	1040	LF
F5	H. V. Plate	3	250	1¼	¼	1043	LF
F6	Mod. Filament	1	250	1¼	¼	1040	LF
F7	L. V. Plate - S/N 1-168	½ Slo-Blo	250	1¼	¼	1266	LF
F7	L. V. Plate - Above S/N 168	1	250	1¼	¼	1040	LF
F8	Mod. Plate Screen	¼	1000	3	13/16	2015	LF
F9	R. F. Filament	1	250	1¼	¼	1040	LF

5.3 RELAYS AND CONTACTORS

Symbol	Function	Coil Voltage	Contact Rating	Energized Cont. Open	Energized Cont. Closed	Unenergized Cont. Open	Unenergized Cont. Closed	Type	Mfr.
K1	Primary Relay	24	3	1	1	1	1	C	CL
K2	Plate Contactor	110	15	0	2	2	0	C7-34	SG
K3	Filament Contactor	110	15	0	2	2	0	C7-34	SG
K4	Tone Relay	24	3	0	2	2	0	C	CL
K5	Antenna	115	6	1	2	2	1	2110	LE

5.4 INDUCTORS

Symbol	Function	Cur. Rating amp.	Freq. Band	Inductance at Rated Cur.	Insulation Voltage	Mgr. Type	Mfr.
L1	H. V. Filter	.600		9 Henries	3000	5105	PR
L2	L. V. Filter	.070		10 Henries	1500	5106	PR
L3	Audio Equalizer					WR128-10-12	AA
L5	OSC. Plate		100-1000 cps.			WR128-20-11	AA
L6, L7	Buffer Plate PA. Grid		200-400 KC			WR128-20-12	AA
L8	PA Variometer		200-400 KC			WR128-7	AA
L9, L10	R-F Transformer		200-400 KC			WR128-43	AA
L11	Ant. Load		200-400 KC	1400 Micro-Henries Max.		WR128-34	AA

5.5 INDICATING INSTRUMENTS

Symbol	Function	Range	Scale	Mfr. Type	Mfr.	Spec.
M1	Mod. Plate Cur.	O-250 MA. D.C.	Standard	NX33	WX	Navy 17-I-12
M2	Osc. Plate Cur.	O-25 MA. D.C.	Standard	NX33	WX	Navy 17-I-12
M3	PA. Plate Cur.	O-300 MA. D.C.	Standard	NX33	WX	Navy 17-I-12
M4	Ant. Cur.	O-3 Amp. R-F	Special	NT-33 N635212	WX	Navy 17-I-12

5.6 RESISTORS

Symbol	Function	Resistance	Mfr. Rating (Watts)	Mfr. Type	Mfr.
R1 **	H. V. Bleeder	15,000	30	ES-C coat-Term. 3 5%	IRC
R2	Audio Attenuator	O-250,000	20 Step	A21-1.5 db 1st 18 steps 33db 19 step. Inf. Att. 20th step	IRC
R3	Audio Amp. Cathode	4800	2	BT-2 10%	IRC
R4	Audio Amp. Screen	2.5 Meg.	2	BT-2 10%	IRC
R5	Audio Amp. Plate	270,000	2	BT-2 10%	IRC
R6	Audio Amp. Plate	33,000	2	BT-2 10%	IRC
R7 **	Bias Supply	600	4.8	DF-C coat-Term. 3 5%	IRC
R8	Audio Driver Grid	390,000	2	BT-2 5%	IRC
R9	Audio Driver Grid	160,000	2	BT-2 5%	IRC
R10 **	Audio Driver Cathode	650	12	DJ-C coat-Term. 3 5%	IRC
R11	Audio Amp. Grid	150,000	2	BT-2 10%	IRC
R12 **	Mod. Screen	15,000 tapped 9400	20	EP-C coat-Term 3 5%	IRC
R13 **	Mod. Screen	6000	16	EN-C coat-Term 3 5%	IRC
R14	Audio Amp. Grid	186,000	2	BT-2 10%	IRC
R15	Audio Amp. Grid	2800	2	BT-2 10%	IRC
R16 **	L. V. Bleeder	20,500	18	DK-C coat-Term 3 5%	IRC
R17 **	Bias Supply	400	4.8	DF-C coat-Term 3 5%	IRC
R18	Osc. Screen	100,000	2	BT-2 10%	IRC
R19 **	Osc. Plate	7500	10	DH-C coat-Term 3 5%	IRC
R20 **	Osc. Grid	100,000	2	BT-2 10%	IRC
R21	Buffer Grid	20,000	2	BT-2 10%	IRC
R22 **	Osc. Cathode	400	4.8	DF-C coat-Term 3 5%	IRC
R23 **	Buffer Screen	6800	10	DH-C coat-Term 3 5%	IRC
R24	PA. Grid	5000	2	BT-2 10%	IRC
R25	PA. Grid	7500	2	BT-2 10%	IRC
R27 **	PA. Screen	11,500	14	ET-C coat-Term 3 5%	IRC
R29 **	Buffer Plate	7000	20	EP-C coat-Term 3 5%	IRC
R30 **	Buffer Screen Bleeder	15,000	16	EN-C coat-Term 3 5%	IRC
R31 **	PA. Plate	10	4.8	DF-C coat-Term 3 5%	IRC
R40	Mod. Grid	50,000 Linear Taper		Type J Bradleyometer Stainless Steel Shaft Screwdriver slot	AB

5.7 SWITCHES

Symbol	Function	Type	Contacts	Current Rating	Voltage Rating	Mfr. Type	Mfr.
S2	Low-Normal Temperature	Link	SPST	—	—	WR 128-5-27	AA
S4	Tone	Lever Key	2A Assembly	3	250	GN 22	CL
S5	Tune-Operate	Tumbler	SPDT	10	250	4963 BLA	BT
					Above S/N, 280	1532	HH
S6	Filament	Tumbler	SPST	10	250	4961 BLA	BT
					Above S/N, 168	1531	HH
S7	Plate	Lever Key	1A Assembly	3	250	GN 21	CL
S8	Tank	Link	SPST	—	—	WR 128-20-15	AA

5.8 TRANSFORMERS—POWER

Symbol	Function	Primary Voltage	Freq.	Prim. VA.	Sec. Voltage	Sec. Current	Mfr. Type	Mfr.
T1	Rec. Fil.	105/110/115/120	60	25	2.5 CT	10.0	5104	PR
T2	H. V. Plate	110/120	60	400	1200 CT	.666	5103	PR
T3	L. V. Plate	110/120	60	40	5.0	3.0		
					940 CT	.085	5102	PR
T7	Mod. Fil.	105/110/115/120	60	17	6.3 CT	2.7	5107	PR
T8	R. F. Fil.	105/110/115/120	60	17	6.3 CT	2.7	5107	PR

5.9 TRANSFORMERS—AUDIO

Symbol	Function	Secondary Impedance	Primary Impedance	Operating Level	Mfr. Type	Mfr.
T4	Audio Input	2800	600/1200	0 to + 4 db	4262	PR
T5	Audio Driver	3100	4000	+ 22 db	4263	PR
T6	Audio Modulator	1940/2700	3800	+ 39.5 db	4264	PR

5.10 TUBE SOCKETS

Symbol	Function	Pins	Material	Mfr. Type	Mfr.
X1	H. V. Rectifier	4	Ceramic	209	EFJ
X2	H. V. Rectifier	4	Ceramic	209	EFJ
X3	L. V. Rectifier	4	Phenolic	MIP4M	AM

5.10 TUBE SOCKETS—Continued

Symbol	Function	Pins	Material	Mfr. Type	Mfr.
X4	Audio Amplifier	8	Phenolic	MIP8M	AM
X5	Audio Driver	8	Phenolic	MIP8M	AM
X6	Modulator	5	Phenolic	MIP5M	AM
X7	Modulator	5	Phenolic	MIP5M	AM
X8	Oscillator	8	Ceramic	RSS8	AM
X9	Buffer	8	Ceramic	RSS8	AM
X10	Power Amplifier	5	Ceramic	225	EFJ
X11	Power Amplifier	5	Ceramic	225	EFJ

5.11 THERMOSTAT

Symbol	Function	Contact Opens	Contact Closes	Mfr. Type	Mfr.
S1	Fan Control	58°F. ± 3°	68°F. ± 3°	4351-18	SP

5.12 CRYSTAL

Symbol	Function	Frequency Range	Spec.	Mfr. Type	Mfr.
A1	Crystal in Holder	200-400 KC	CAA509-4-2	AC 95 E	AA

5.13 INDICATOR LIGHT

Symbol	Function	Voltage	Watts	Bulb	Base	Mfr.
I1	Filament Pilot	120	6	S-6	Candelabra	GE

5.14 CHASSIS CONNECTORS—PLUGS AND SOCKETS

Symbol	Function	Terminals Omitted	Mfr. Type	Mfr.
P1	Power Unit	2-3-6 S/N 1-168 8-9-12 above 168	P406AB1/16	JO
J1	Power Unit		S406AB	JO
P2	Power Unit	Standard	P412AB1/16	JO
J2	Power Unit		S412AB	JO
P3	Mod. Unit	Standard	P412AB1/16	JO
J3	Mod. Unit		S412AB	JO
P4	Mod. Unit	5-6-9-10	P410AB1/16	JO

5.14 CHASSIS CONNECTORS—PLUGS AND SOCKETS—Continued)

Symbol	Function	Terminals Omitted	Mfr. Type	Mfr.
J4	Mod. Unit		S410AB	JO
P5	R. F. Unit	2-3-6 S/N 1-168 8-9-12 above S/N 168	P406AB1/16	JO
J5	R. F. Unit		S406AB	JO
P6	R. F. Unit	Standard	P410AB1/16	JO
J6	R. F. Unit		S410AB	JO
P7	R. F. Unit	Special	WR128-25-13	AA
J7	R. F. Unit	Standard	72	EFJ
P8	Load Coil Unit	Special	WR 128-25-13	AA
J8	Load Coil Unit	Standard	72	EFJ
P9	Load Coil Unit	Standard	P404AB1/16	JO
J9	Load Coil Unit		S404AB	JO
P10	Load Coil Unit	Special	WR 128-25-13	AA
J10	Load Coil Unit	Standard	72	EFJ
P11	Load Coil Unit	Special	WR 128-25-13	AA

5.15 CHASSIS CONNECTORS—PATCH CORDS

Symbol	Function	Terminals Omitted	Mfr. Type	Mfr.
PP1	Power Unit	2-3-6 S/N 1-168 8-9-12 Above S/N 168	P406CCT	JO
PJ1	Power Unit		S406CCT	JO
PP2	Power Unit	Standard	P412CCT	JO
PJ2	Power Unit		S412CCT	JO
PP3	Mod. Unit	Standard	P412CCT	JO
PJ3	Mod. Unit		S412CCT	JO
PP4	Mod. Unit	5-6-9-10	P410CCT	JO
PJ4	Mod. Unit		S410CCT	JO
PP5	R. F. Unit	2-3-6 S/N 1-168 8-9-12 Above S/N 168	P406CCT	JO
PJ5	R. F. Unit		S406CCT	JO
PP6	R. F. Unit	Standard	P410CCT	JO
PJ6	R. F. Unit		S410CCT	JO
PP9	Load Coil Unit	Standard	P404CCT	JO
PJ9	Load Coil Unit		S404CCT	JO

5.16 MISCELLANEOUS

Function	Symbol	Mfr. Type	Mfr.
Flexible Coupling		250	EFJ
Attenuator Knob		637J S/N 1-168 S-311-64L Above S/N 168	GR KK
Dial		710A S/N 1-168 294 Above S/N 168	GR CR
Dial Lock		520A S/N 1-168 10050 Above S/N 168	GR MN
Blower Motor	Bl	Type KSC, Frame 62H 1/50 HP, 1725 RPM, 115 volts 1 phase, 60 cycles, Capacitor, S/N 1-168	GE
Blower Motor	Bl	Model 123, Type R, 115 volts 1/30 HP, 1525 RPM, 50-60 cycles Above S/N 168	RD
Blower Wheel		"O" CCW, 4½ x 2¼, inside Hub 5/16" Bore, S/N 1-168 A452, CCW, Inside Hub, Allen set screw, 5/16" Bore, Bright Zinc Plate. Above S/N 168	TO TO
Dust Filter		Fiber Glas #1-10 x 10 x 1	OC
Lamp Socket		Socket-Bullseye-CHR 601 Red Insert	KI
Blower Plug	P13	Midget Cord Connector MC	HH
Blower Socket	J13	Flush Receptacle-752	HH

* Foil paper capacitors are manufactured in accordance with Navy Specification RE13A 488C, however manufacturers type numbers appear.

** Resistors are manufactured in accordance with Navy Specification RE13A372J for Grade 1, Class 2.

MAINTENANCE

5.17 CONTACTOR AND RELAY PARTS LIST

ANTENNA CONTACTOR K5

Leach Relay Co. Type #2110.

Refer to Fig. 20.

Item No.	Description	Material	Size	Quantity
1	Moving Contact Assembly	Silver Contacts	¼″ Diameter	3
2	Cross Arm	Mycalex	⅛″ thick	1
3	Front Stationary Contact Assembly	Silver Contacts	¼″ Diameter	2
4	Back Stationary Contact Assembly	Silver Contacts	¼″ Diameter	1
5	Coil #374 115V	50-60 Cycles		1
6	Spring	Stainless Steel		1
7	Insulators	Isolantite #483	¾″ Diameter	6
8	Insulators	Isolantite #484	¾″ Diameter	6
9	Base	Natural Paper base Bakelite	⅛″ thick	1
10	Sub-base	Natural Paper base Bakelite	⅛″ thick	1
11	Cross Arm Mounting screws			

PLATE AND FILAMENT CONTACTORS, K2 AND K3

Signal Engineering and Mfg. Co. Type C7-34 Relay

Refer to Fig. 18

Item No.	Description	Mfr. Part No.	Quantity
1	#4 Washer N. P. Brass	P-11224	1
2	#6-32 x ¼″ Binding Hd. Screw N. P.	P-11255	8
3	#2-56 x 13/16″ Rd. Head Steel Screw N. P.	P-11541	2
4	#4-36 x 7/16″ Rd. Head Steel Screw N. P.	P-11543	1
5	#6-32 x 5/16″ Cup Point Set Screw	P-11483	1
6	#4 Lockwasher	P-11545	1

PARTS LIST

PLATE & FILAMENT CONTACTORS K2 and K3

Signal Engineering and Mfg. Co., Type C7-34 Relay (Cont'd.)

Item No.	Description	Mfr. Part No.	Quantity
7	A. C. Core Assembly	PA-51001	1
8	Base Terminal	P-51012	6
9	Name Plate	P-51019	1
10	Bracket	P-51021	1
11	Spring Adjusting Screw	P-51022	1
12	Spring	P-51023	1
13	Relay Base	PA-51026	1
14	Armature Assembly	PA-51044	1
15	Shading Coil	P-51051	2
16	Contact Post	PA-51070	4
17	Coil	#34 Coil Spec. X-101	1

PRIMARY AND TONE RELAYS K1 AND K4

C. P. Clare, Type C, A 10647 and B 10647

Refer to Figure 19

Item No.	Description	Material	Mfr. Part No.	Quantity
2	Coil Assembly		W2-1027-1	1
3	Heel Piece		RP-1108G3	1
4	Rt. Hand Armature Assembly		RP-24G-7	1
5	#8-32 Fil. H. M. S.	Steel ⅜" long cad.		1
6	Rt. Hand Armature Backstop	HH. Brass wh. ni.	RP-507	1
7	Pileup Insulator Per Al		RP-504 GwZ	
8	Contact Assembly for Relay A-10647		1 Form C)	
	Contact Assembly for Relay B-10647		2 Form A)	1
9	Clamping Washer			1
10	#6-32 Pileup Screw			2

5.18 LIST OF MANUFACTURERS

Code	Full Name	Address
AA	Air Associates, Inc.	Airport Way & Century Blvd., Los Angeles, Calif.
AB	Allen Bradley Co.	Milwaukee, Wis.
AM	American Phenolic Corp.	Cicero Postoffice, Chicago, Ill.
BD	Bud Radio, Inc.	Cleveland, Ohio
BT	Bryant Electric Company	1421 State Street, Bridgeport, Conn.
BN	Bussman Mfg. Company	Division-McGraw Electric Co., St. Louis, Mo.
CL	C. P. Clare & Company	Lawrence and Lamon Ave., Chicago, Ill.
CR	Crowe Nameplate & Mfg. Co.	3701 Ravenswood Ave., Chicago, Ill.
GE	General Electric Company	Schenectady, N. Y.
GR	General Radio Company	30 State Street, Cambridge, Mass.
HH	Arrow-Hart & Hegemen Electric Co.	Hartford, Conn.
IRC	International Resistance Co.	Philadelphia, Pa.
EFJ	E. F. Johnson Company	Waseca, Minn.
JO	Howard B. Jones	2300 Wabansia Ave., Chicago, Ill.
KI	Kirkland Company	8 King Street, Morristown, N. J.
KK	Kurz-Kasch, Inc.	1421 S. Broadway, Dayton, Ohio
LE	Leach Relay Company	5915 Avalon Blvd., Los Angeles, Calif.
LF	Littelfuse, Inc.	4757 Ravenswood Ave., Chicago, Ill.
MN	James Millen Mfg. Co.	Malden, Mass.
OC	Owens-Corning Fiberglas Corp.	Toledo, Ohio
PR	Peerless Electrical Prod. Co.	6920 McKinley Ave., Los Angeles, Calif.
RD	A. G. Redmond Co.	Owosso, Mich.
SO	Sangamo Electric Company	Springfield, Ill.
SG	Signal Engineering & Mfg. Co.	154 W. 14th St., New York City, N. Y.
SR	Solar Mfg. Corp.	Bayonne, N. J.
SP	Spencer Thermostat Co.	Attleboro, Mass.
TO	Torrington Mfg. Co.	Torrington, Conn.
WX	Westinghouse Elec. & Mfg. Co. Newark Works	Newark, N. J.

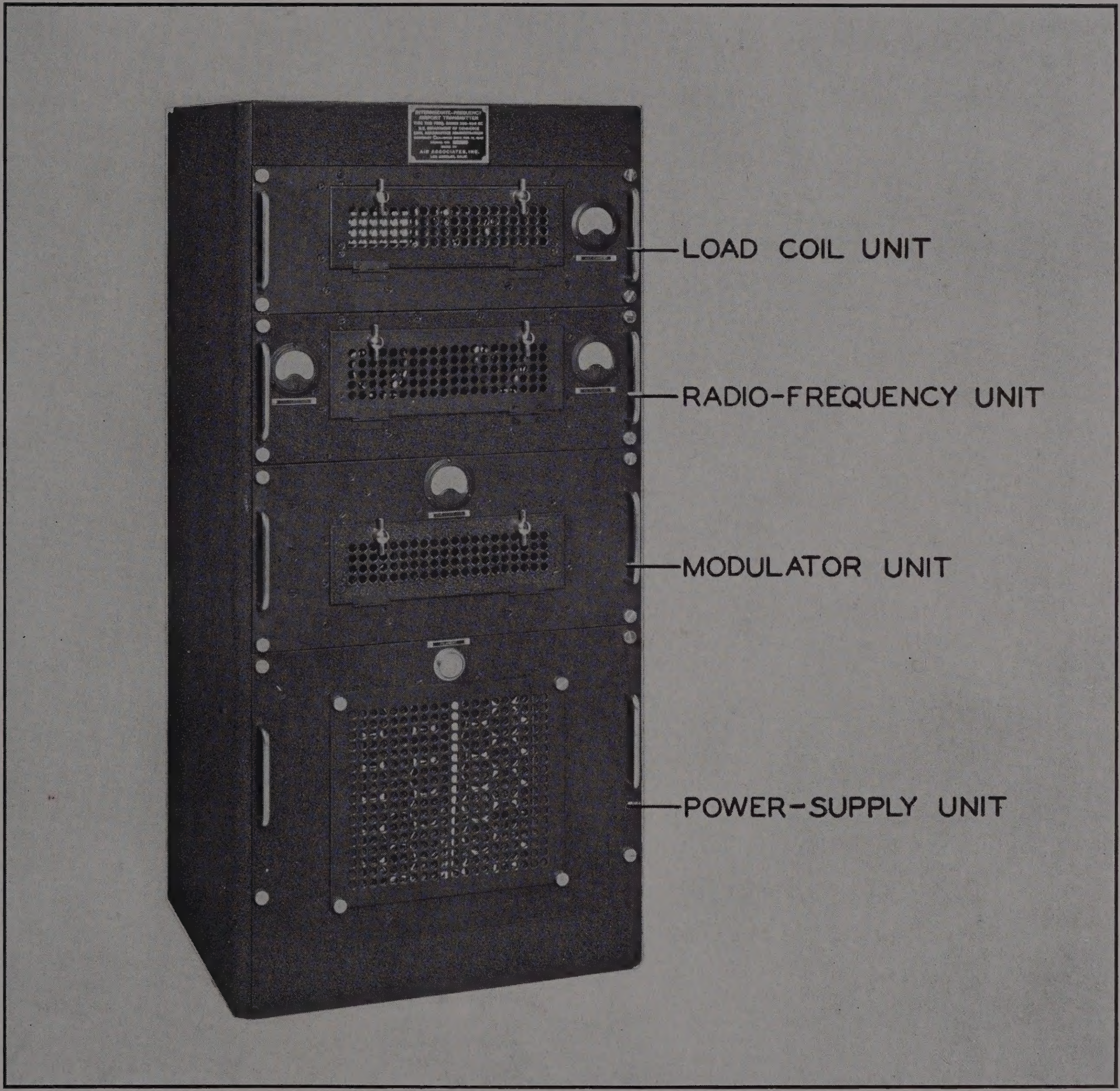

LOAD COIL UNIT
RADIO-FREQUENCY UNIT
MODULATOR UNIT
POWER-SUPPLY UNIT

Fig. 1. Type TMO Transmitter—Front View

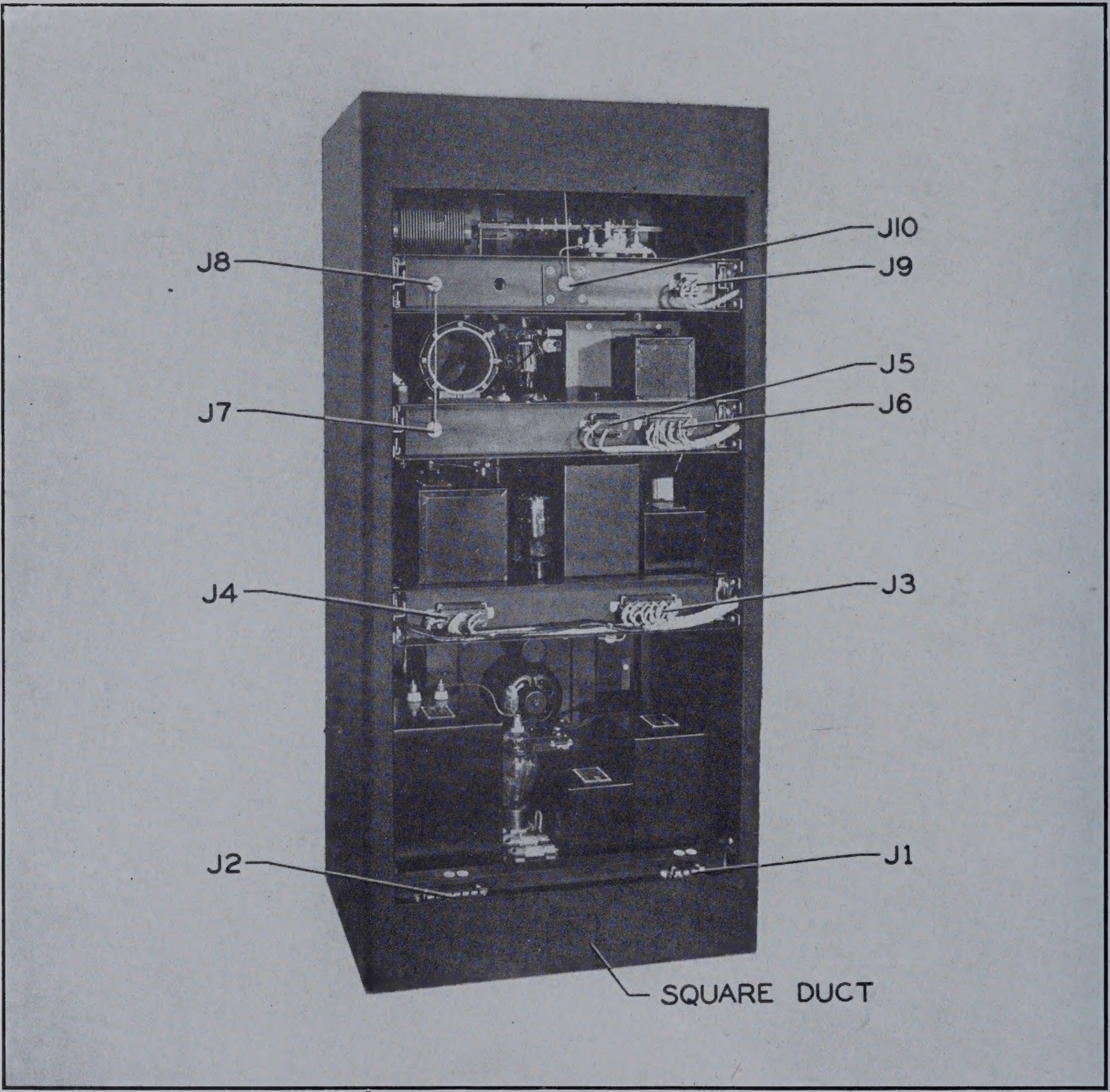

J8
J10
J9
J5
J7
J6
J4
J3
J2
J1
SQUARE DUCT

Fig. 2. Type TMO Transmitter—Rear View—Cover Removed

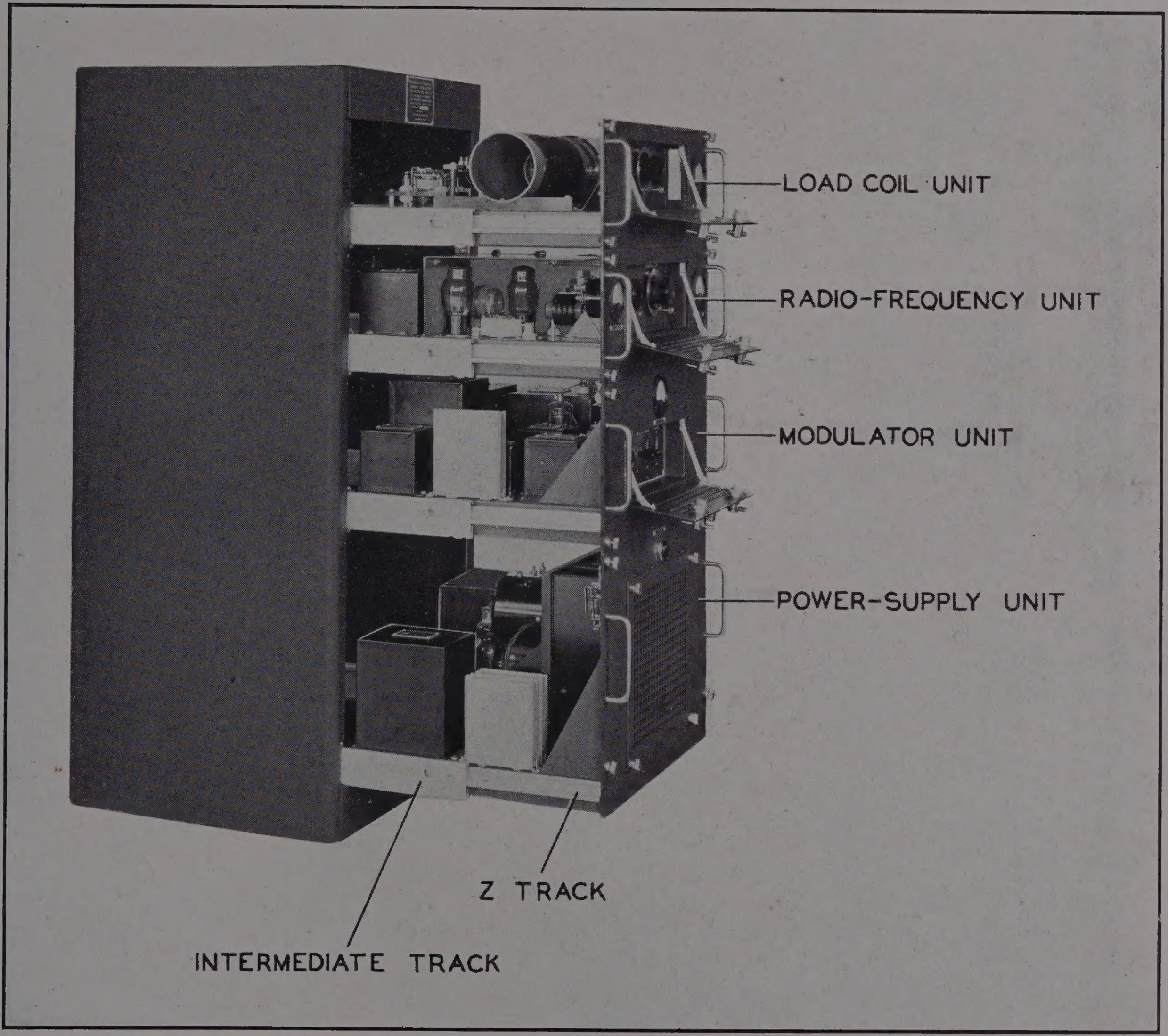

LOAD COIL UNIT
RADIO-FREQUENCY UNIT
MODULATOR UNIT
POWER-SUPPLY UNIT
Z TRACK
INTERMEDIATE TRACK

Fig. 3. Type TMO Transmitter—Left Side View—Units Withdrawn

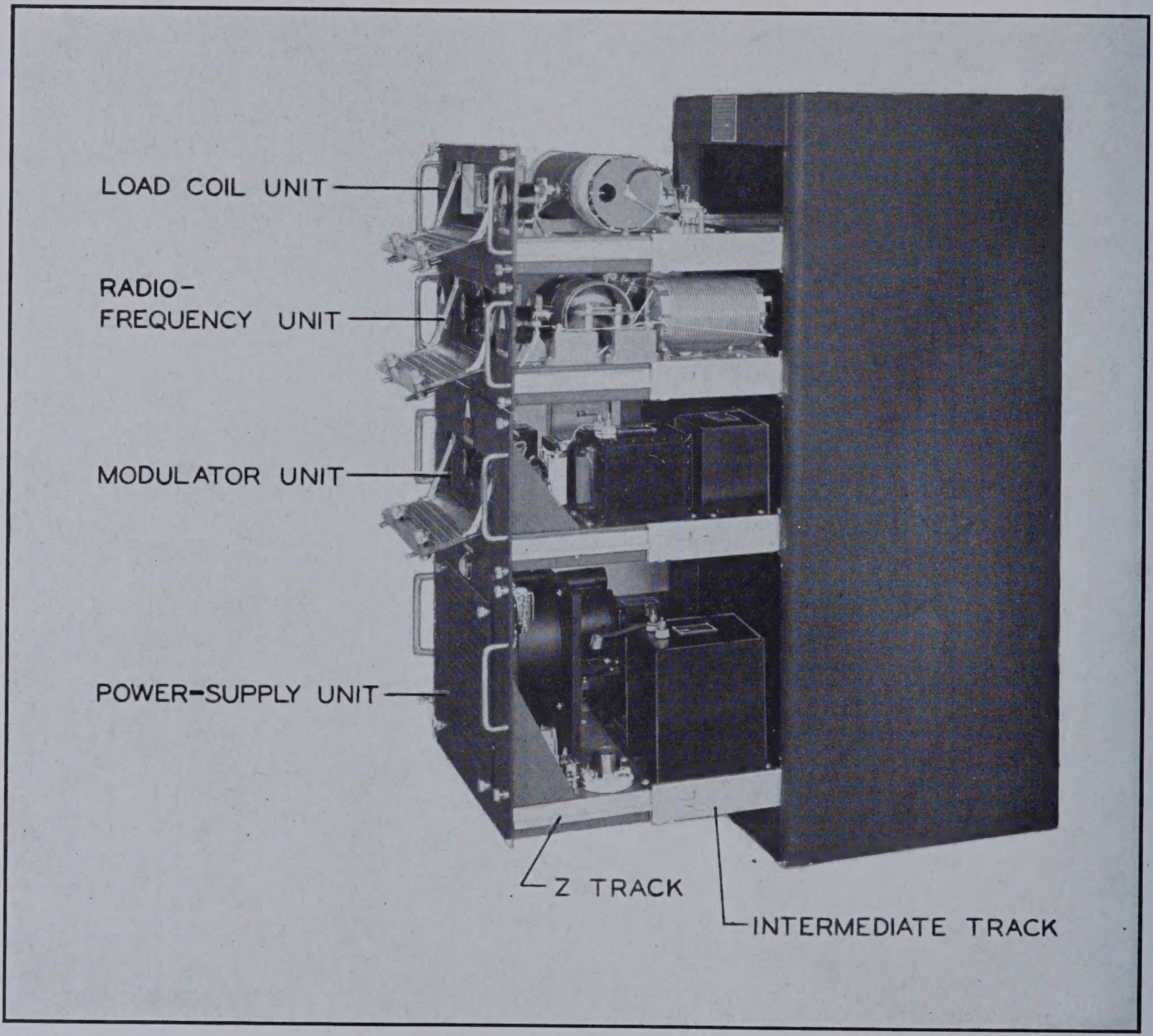

LOAD COIL UNIT
RADIO-FREQUENCY UNIT
MODULATOR UNIT
POWER-SUPPLY UNIT
Z TRACK
INTERMEDIATE TRACK

Fig. 4. Type TMO Transmitter—Right Side View—Units Withdrawn

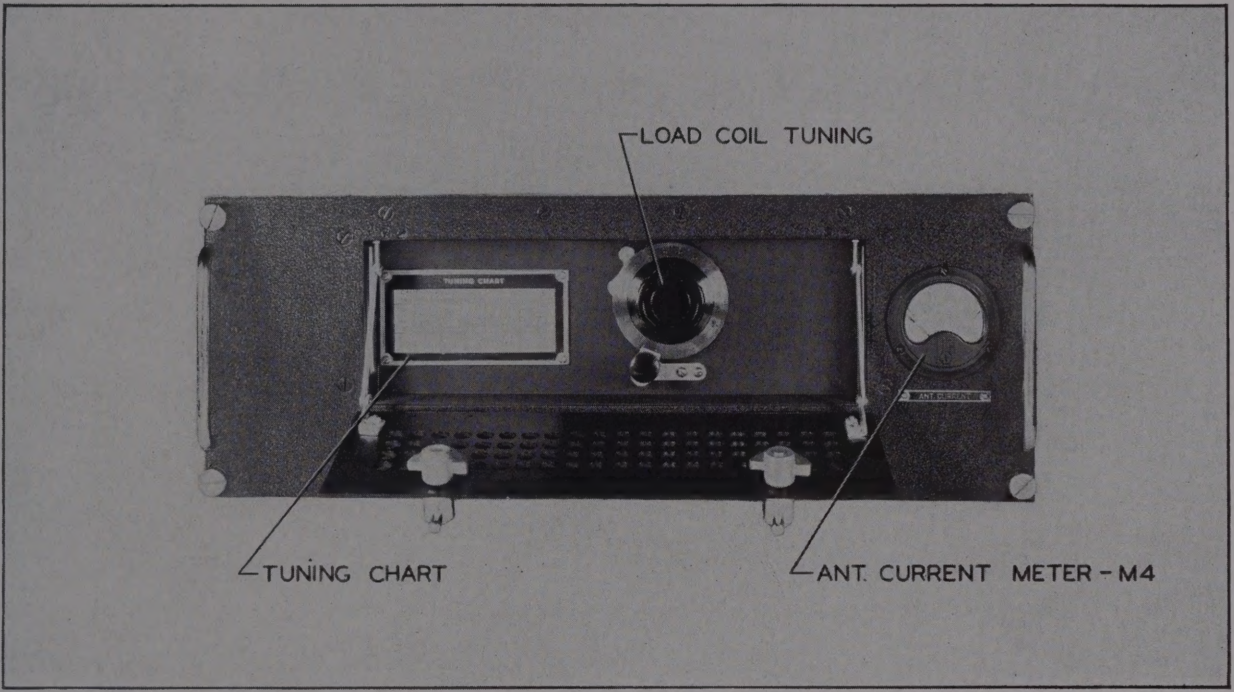

LOAD COIL TUNING
TUNING CHART
ANT. CURRENT
TUNING CHART
ANT. CURRENT METER - M4

Fig. 5. TMO Load Coil Unit—Front View

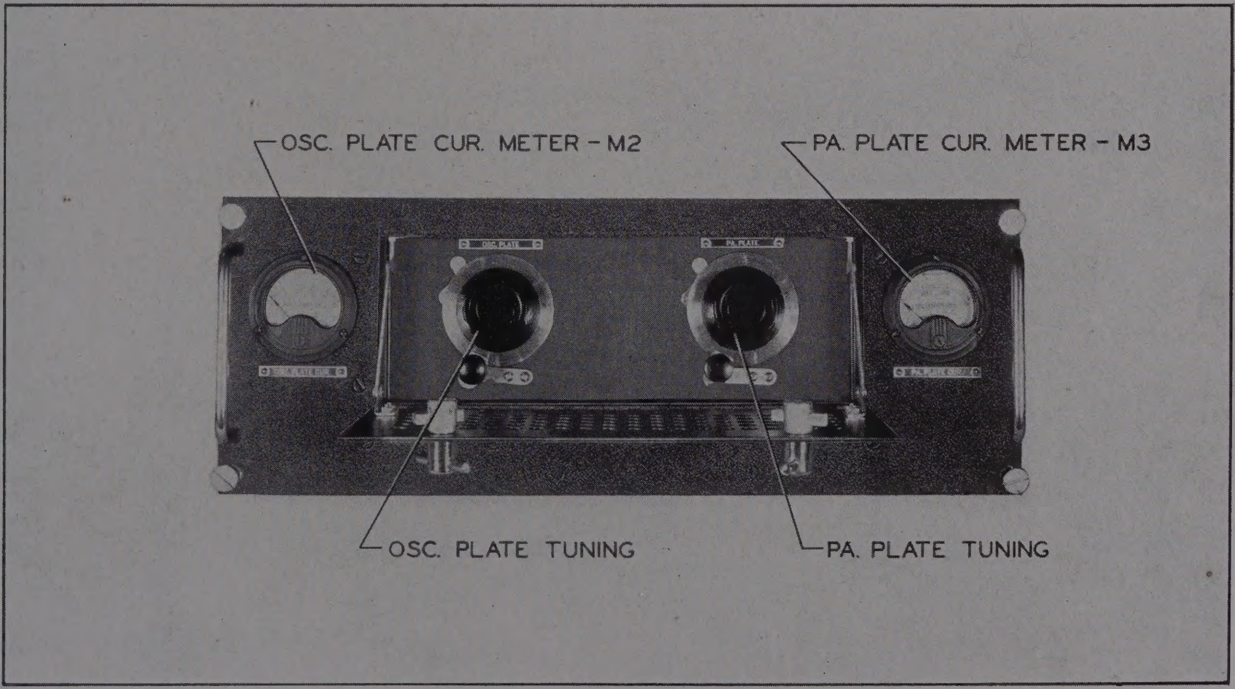

OSC. PLATE CUR. METER - M2
PA. PLATE CUR. METER - M3
OSC. PLATE
PA. PLATE
OSC. PLATE TUNING
PA. PLATE TUNING

Fig. 6. TMO Radio-Frequency Unit—Front View

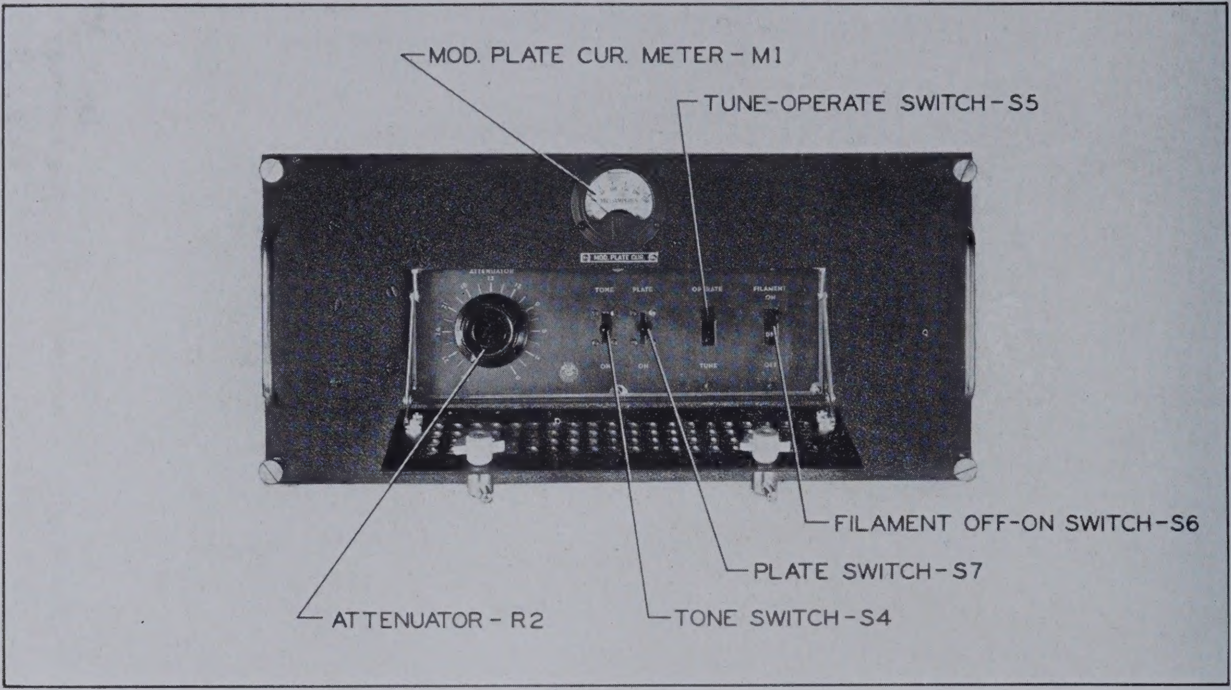

MOD. PLATE CUR. METER - M1
TUNE-OPERATE SWITCH - S5
FILAMENT OFF-ON SWITCH - S6
PLATE SWITCH - S7
ATTENUATOR - R2
TONE SWITCH - S4

Fig. 7. TMO Modulator Unit—Front View

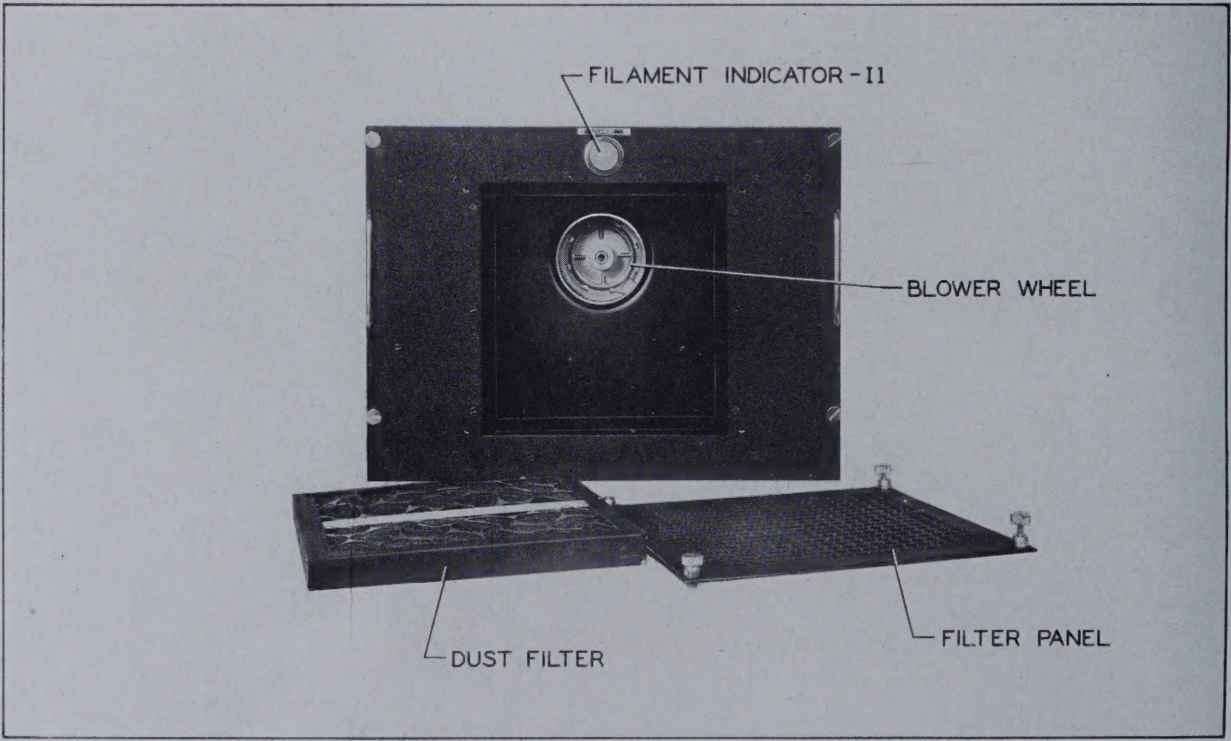

FILAMENT INDICATOR - I1
BLOWER WHEEL
DUST FILTER
FILTER PANEL

Fig. 8. TMO Power-Supply Unit—Front View

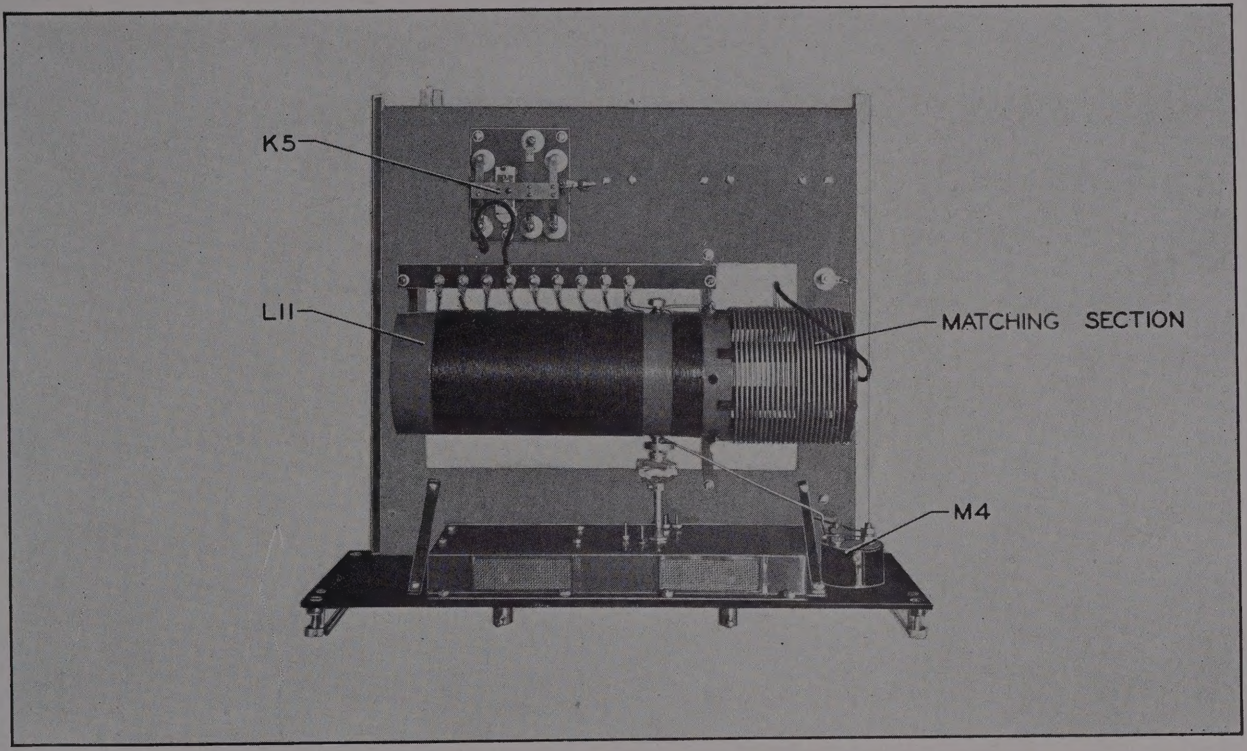

K5
L11
MATCHING SECTION
M4

Fig. 9. TMO Load Coil Unit—Top View

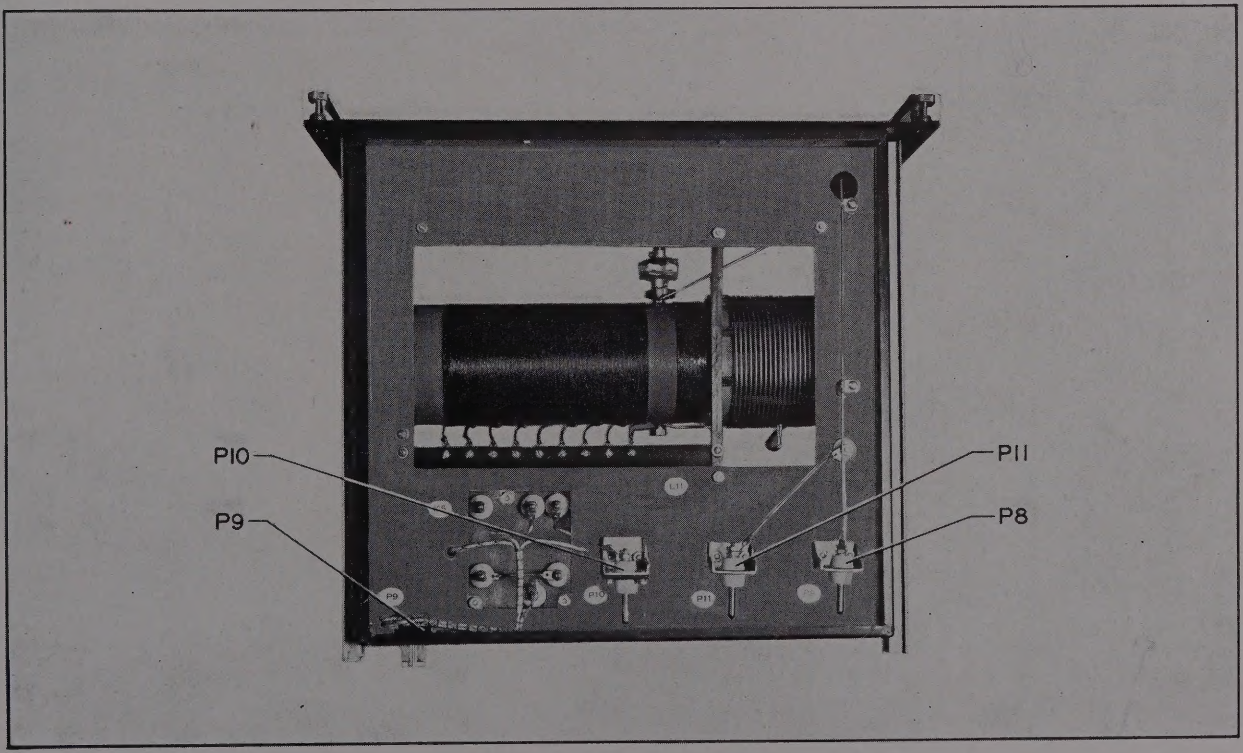

P10
P9
P11
P8

Fig. 10. TMO Load Coil Unit—Bottom View

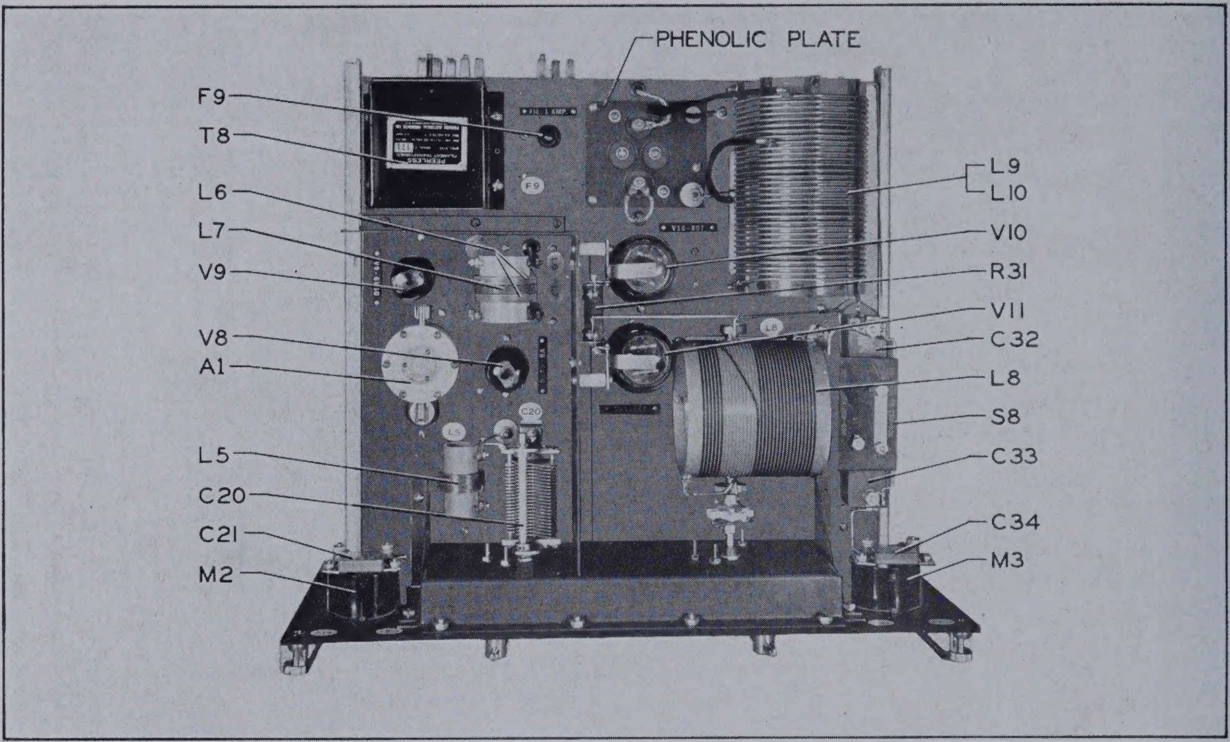

PHENOLIC PLATE
F9
T8
L6
L7
V9
V8
A1
L5
C20
C21
M2
L9
L10
V10
R31
V11
C32
L8
S8
C33
C34
M3

Fig. 11. TMO Radio-Frequency Unit—Top View

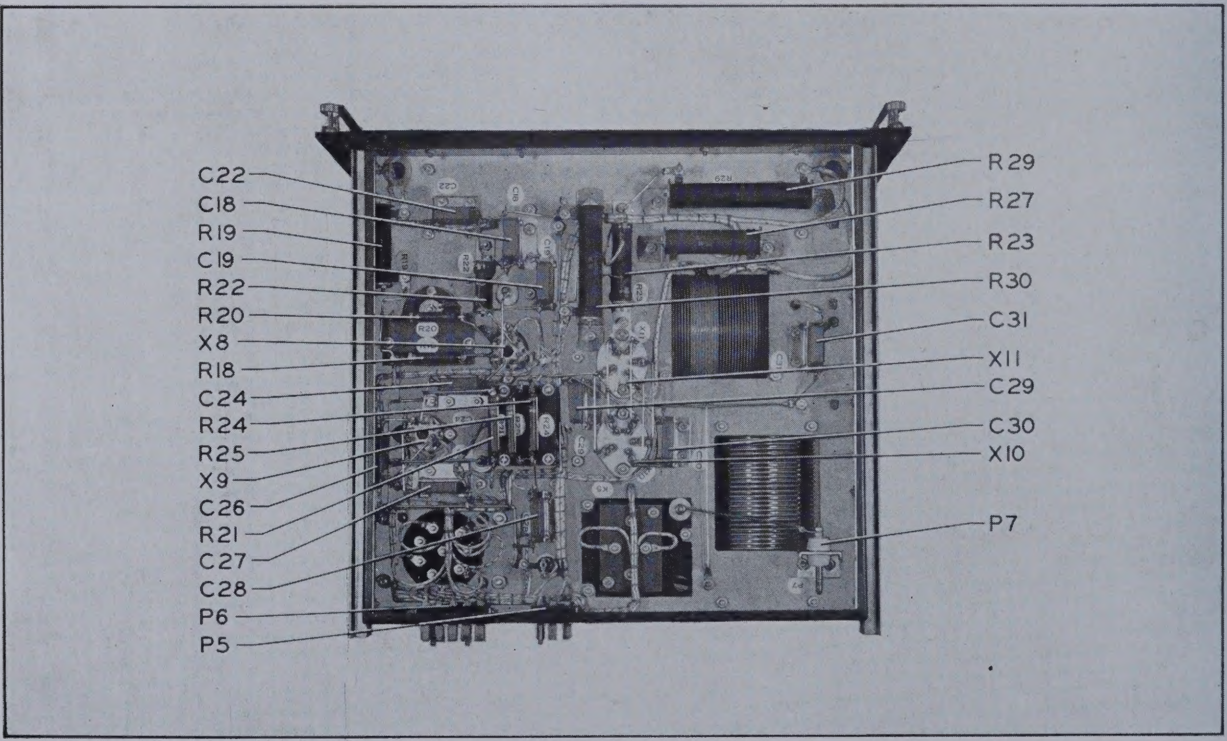

C22
C18
R19
C19
R22
R20
X8
R18
C24
R24
R25
X9
C26
R21
C27
C28
P6
P5
R29
R27
R23
R30
C31
X11
C29
C30
X10
P7

Fig. 12. TMO Radio-Frequency Unit—Bottom View

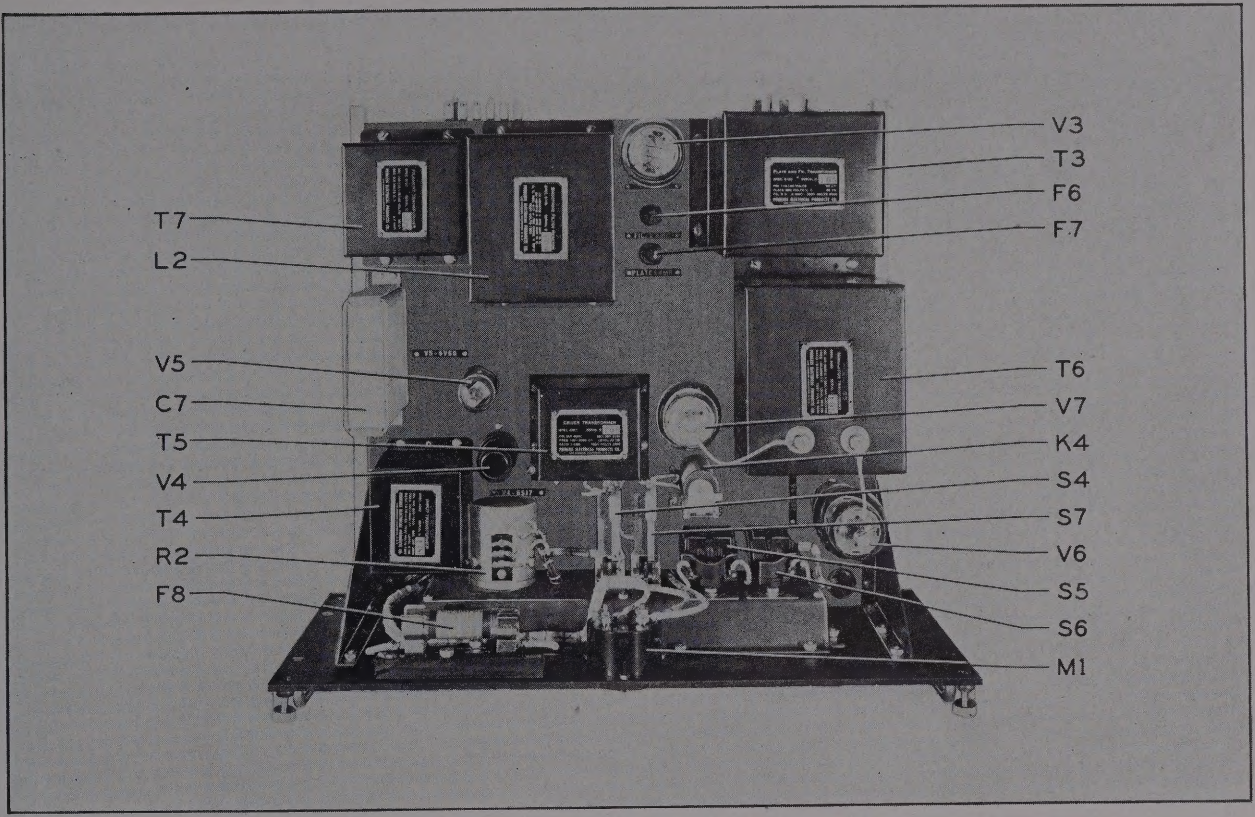

T7
L2
V5
C7
T5
V4
T4
R2
F8
V3
T3
F6
F7
T6
V7
K4
S4
S7
V6
S5
S6
M1

Fig. 13. TMO Modulator Unit—Top View

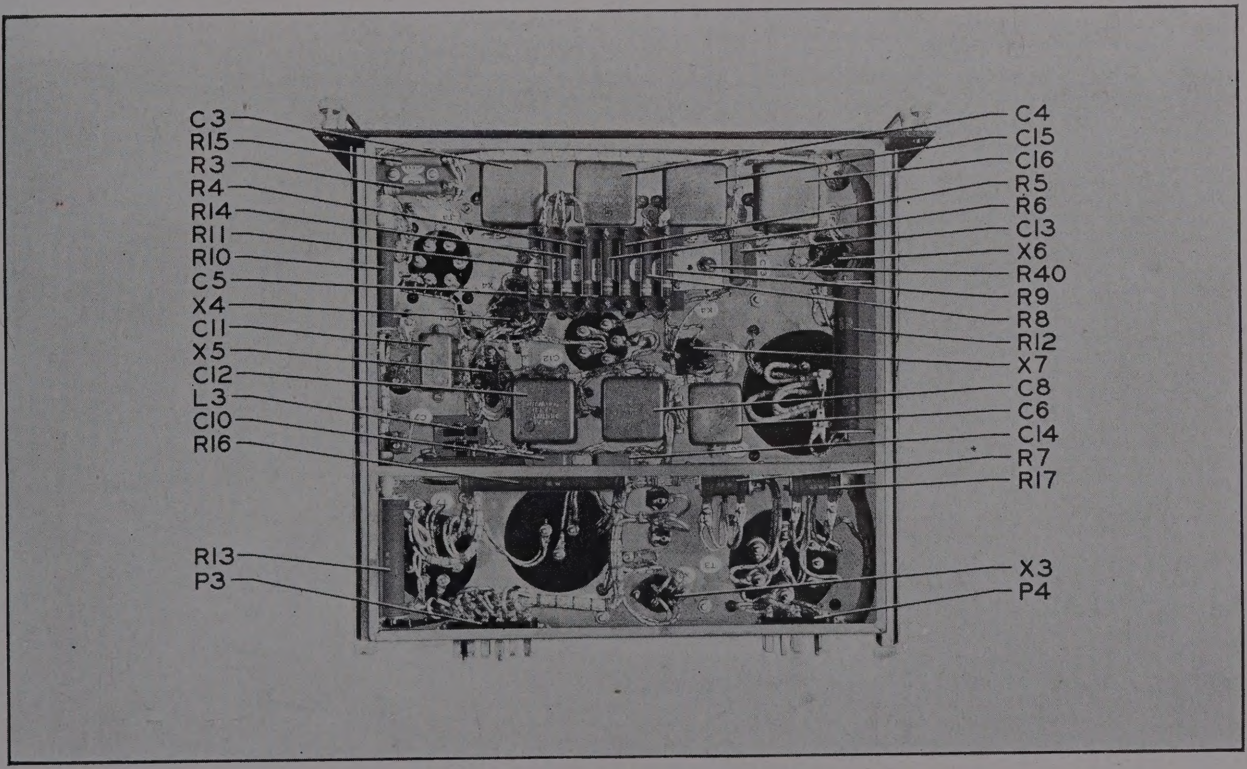

C3
R15
R3
R4
R14
R11
R10
C5
X4
C11
X5
C12
L3
C10
R16
R13
P3
C4
C15
C16
R5
R6
C13
X6
R40
R9
R8
R12
X7
C8
C6
C14
R7
R17
X3
P4

Fig. 14. TMO Modulator Unit—Bottom View

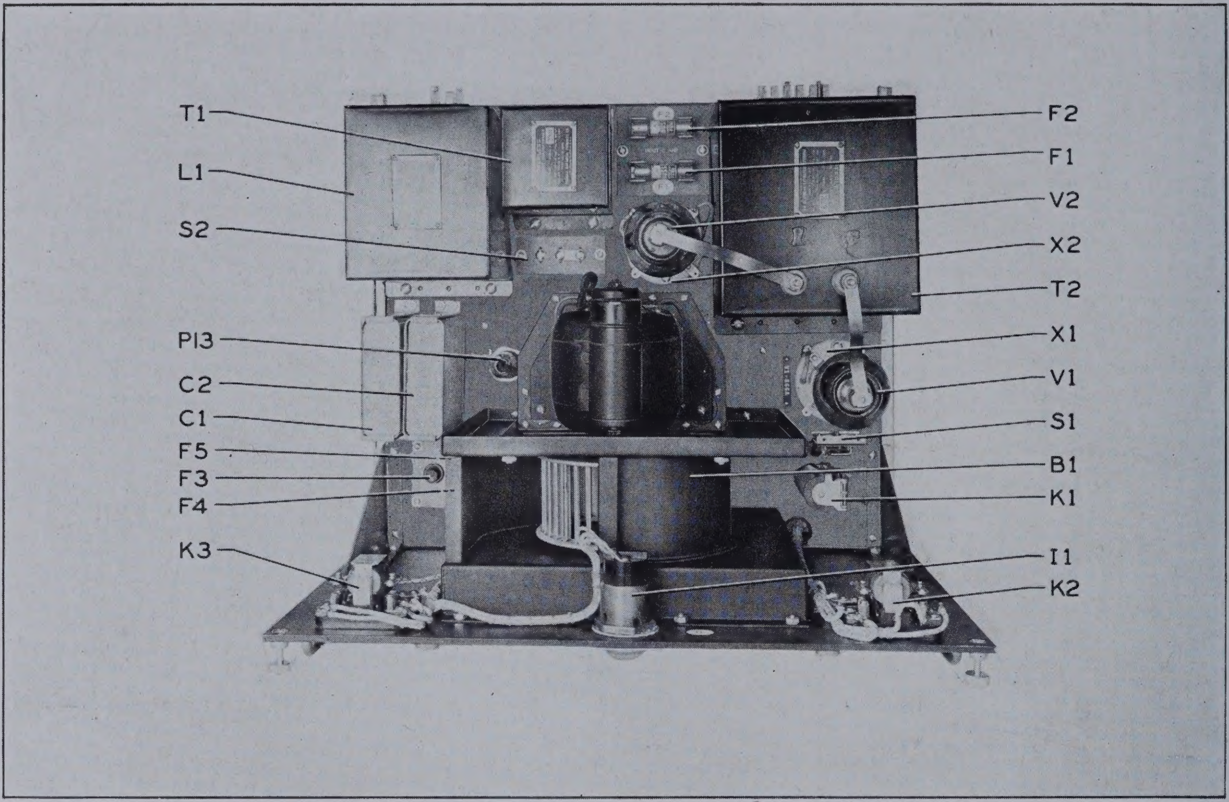

T1
L1
S2
PI3
C2
C1
F5
F3
F4
K3
F2
F1
V2
X2
T2
X1
V1
S1
B1
K1
I1
K2

Fig. 15. TMO Power-Supply Unit—Top View

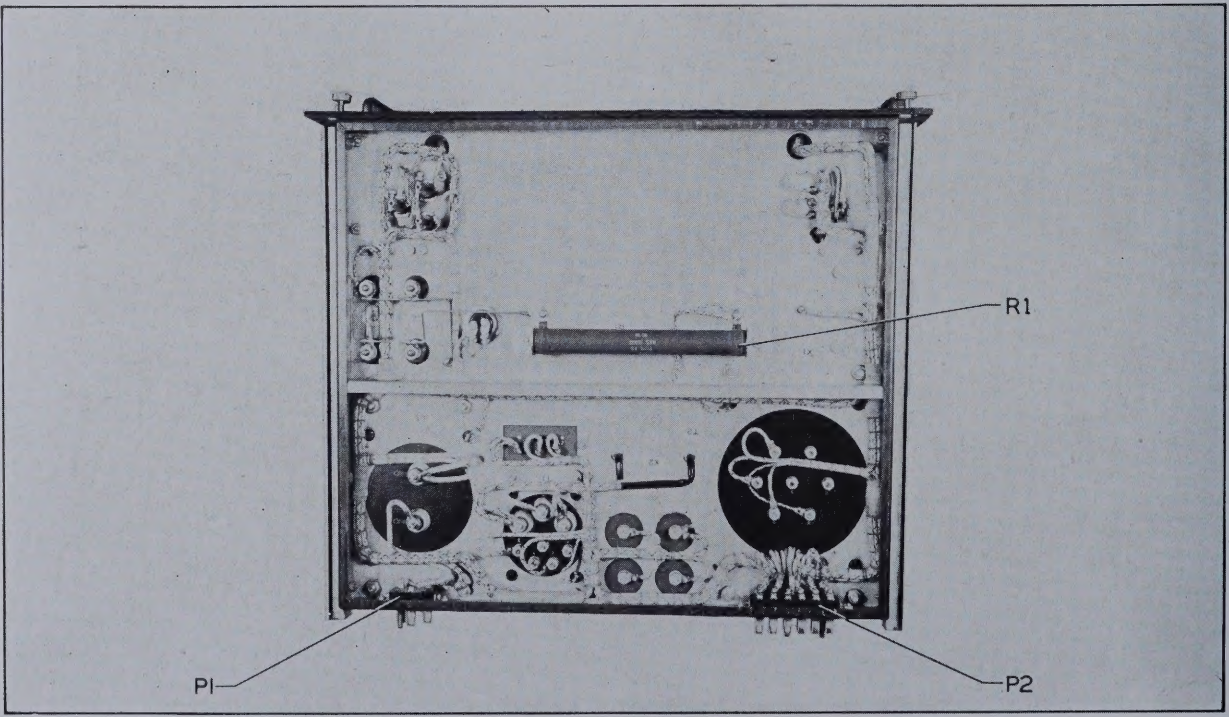


Fig. 16. TMO Power-Supply Unit—Bottom View

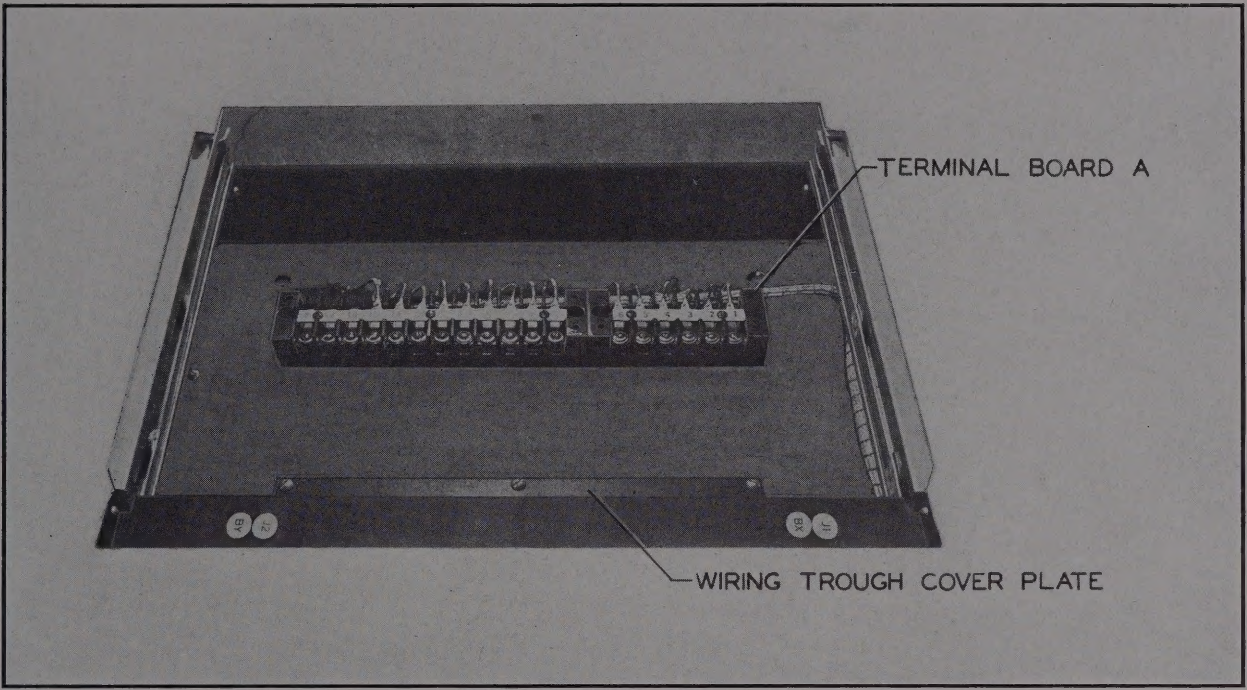

TERMINAL BOARD A
WIRING TROUGH COVER PLATE
BY
J2
BX
J1

Fig. 17. Incoming Wiring Terminal Block—Unit A

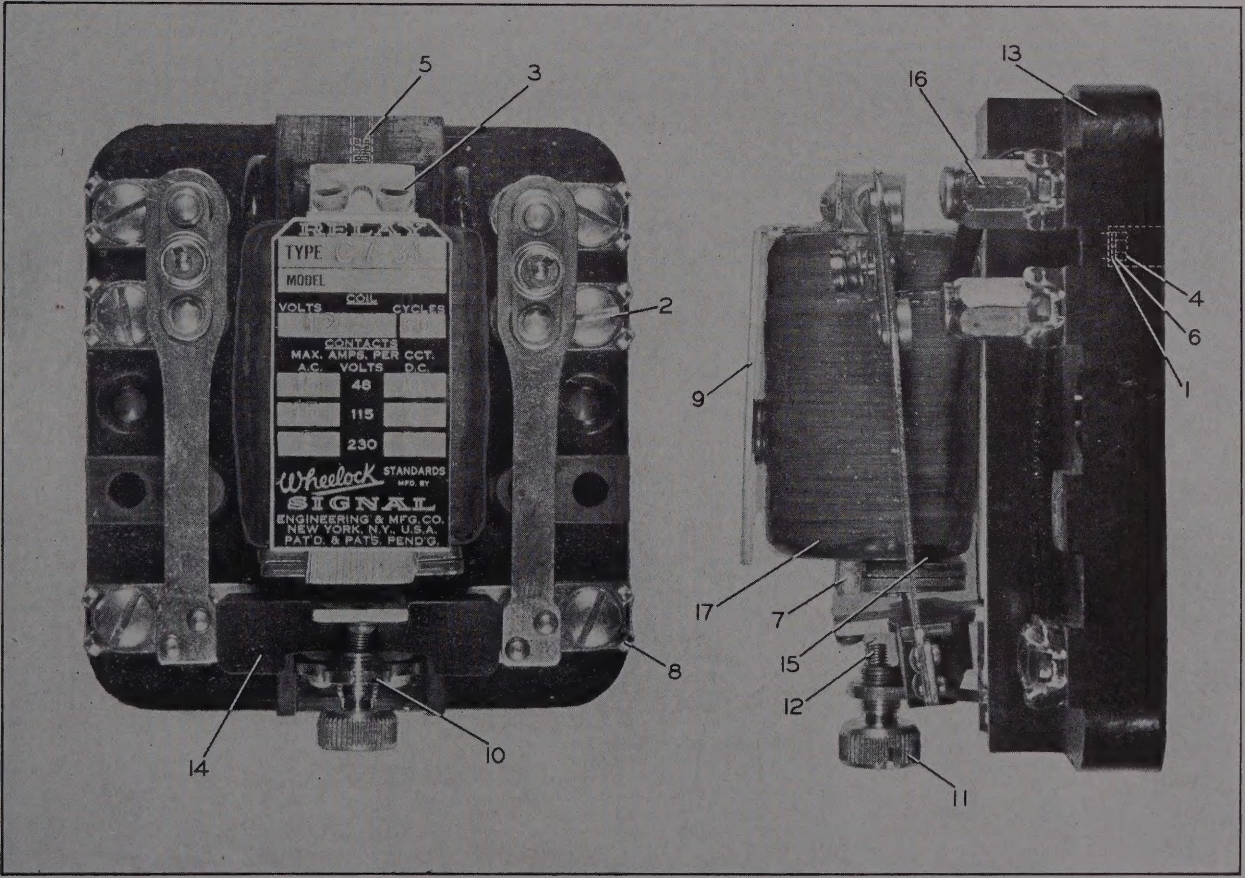

5
3
2
8
10
14
RELAY
TYPE
MODEL
COIL
VOLTS
CYCLES
CONTACTS
MAX. AMPS. PER CCT.
A.C.
VOLTS
D.C.
48
115
230
Wheelock
STANDARDS
MFD. BY
SIGNAL
ENGINEERING & MFG. CO.
NEW YORK, N.Y., U.S.A.
PAT'D. & PATS. PEND'G.
13
16
4
6
1
9
17
7
15
12
11

Fig. 18. Plate and Filament Contactors K2 and K3—Top and Side View

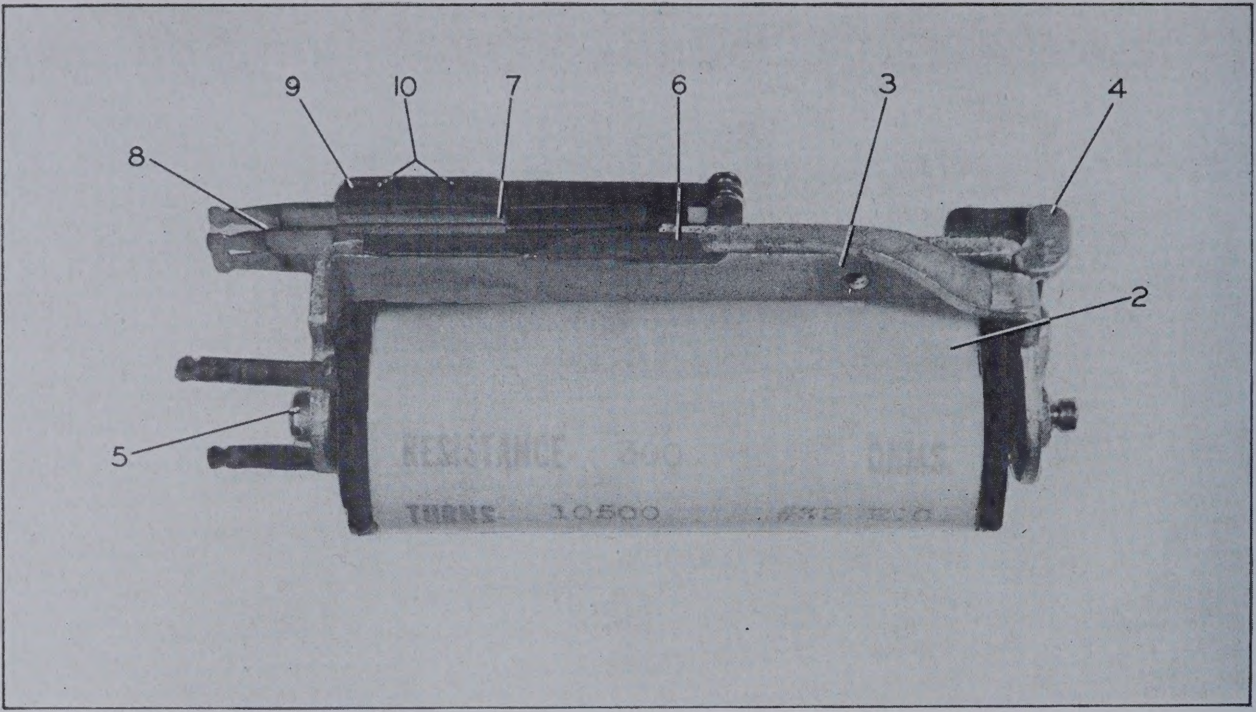

9
10
7
6
3
4
8
2
5
RESISTANCE
OHMS
TURNS 10500

Fig. 19. Primary Relay K1 and Tone Relay K4

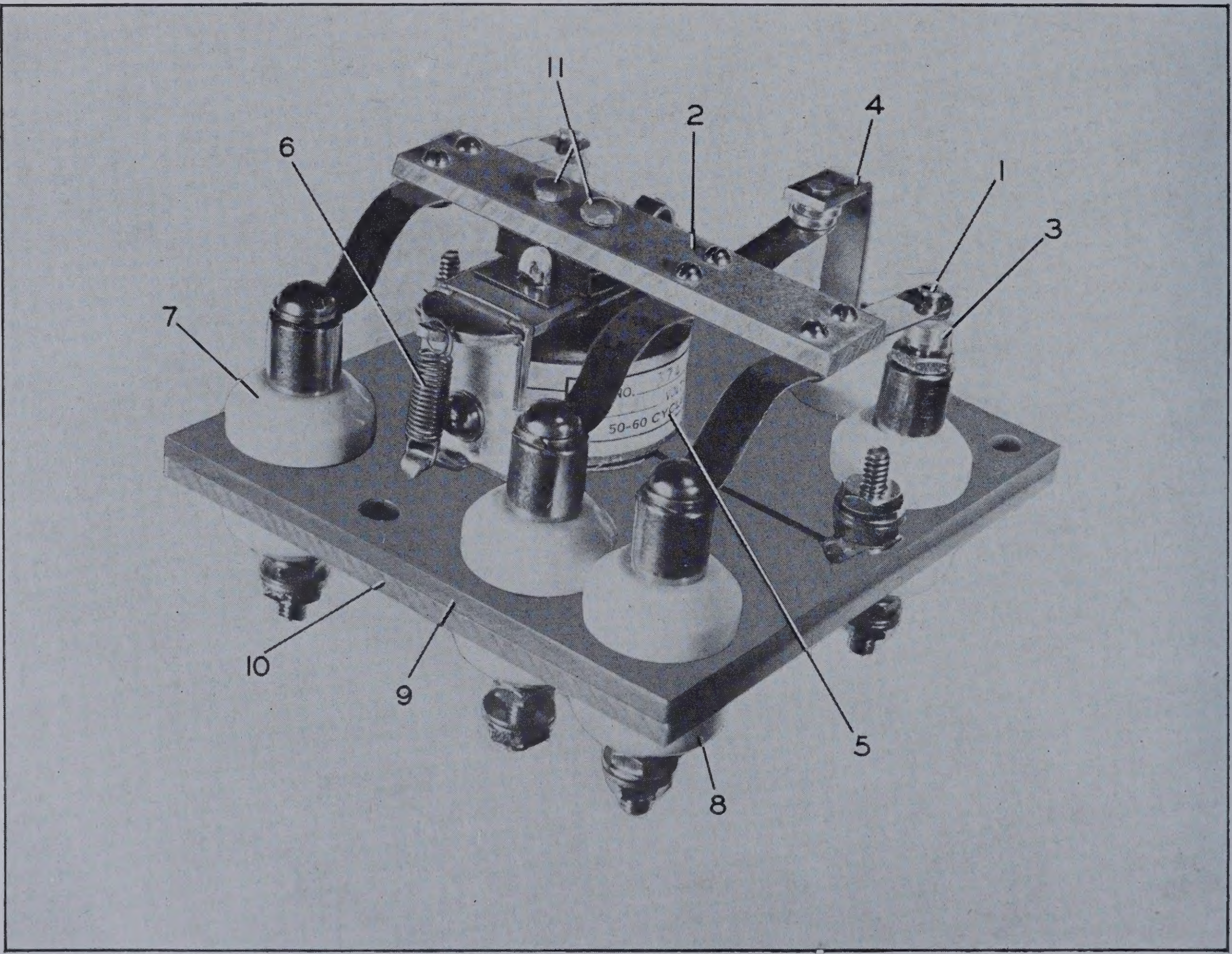

11
2
4
6
1
3
7
50-60 CY
10
9
5
8

Fig. 20. Antenna Contactor K5

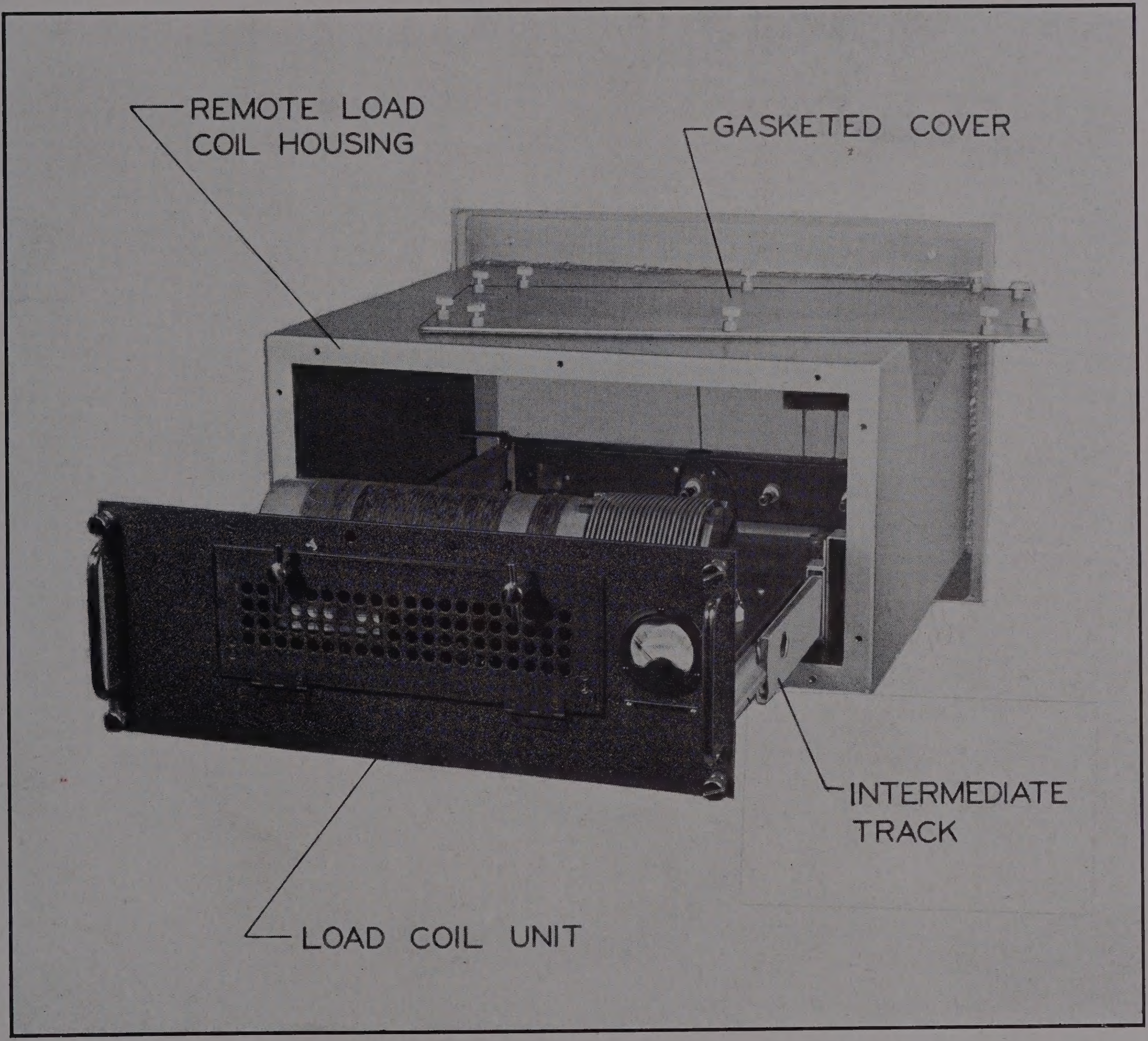

REMOTE LOAD COIL HOUSING
GASKETED COVER
INTERMEDIATE TRACK
LOAD COIL UNIT

Fig. 21. TMO Load Coil Unit in Remote Housing

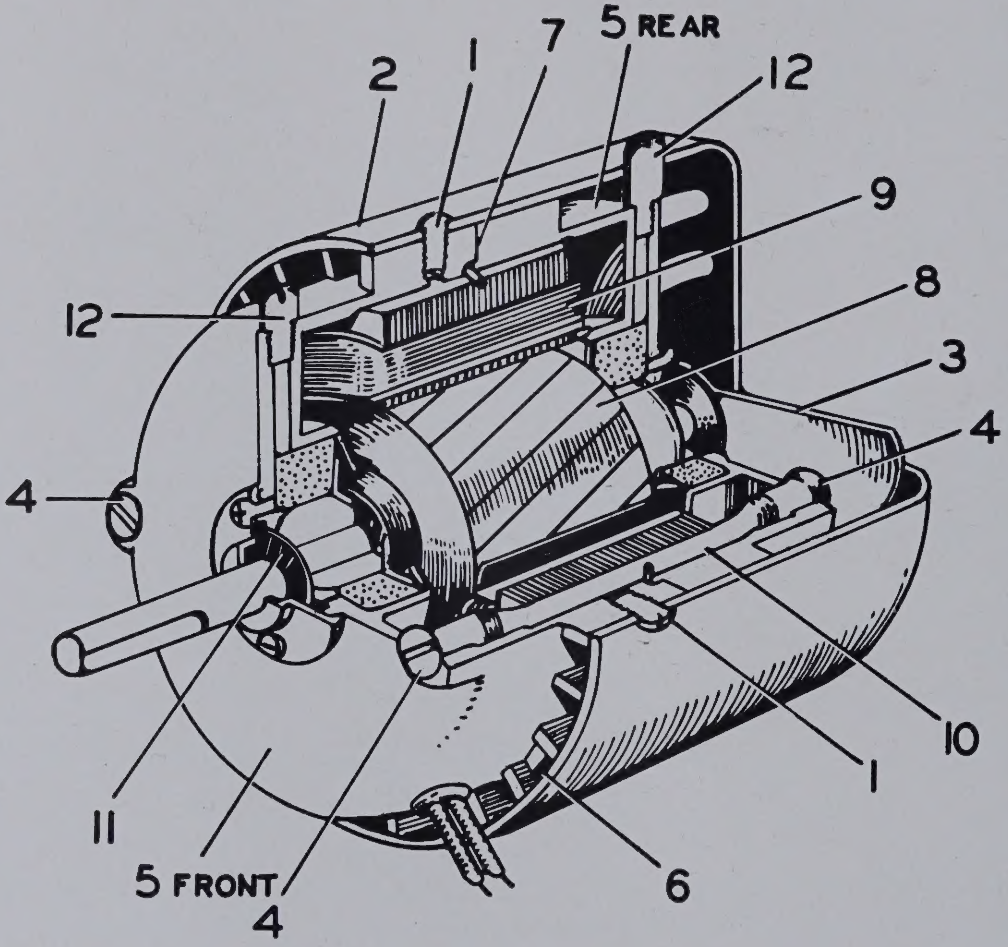

5 REAR
7
1
2
12
9
12
8
3
4
4
10
1
11
6
5 FRONT
4

Fig. 22. Blower Motor, A. G. Redmond Co., Type R., Model 123

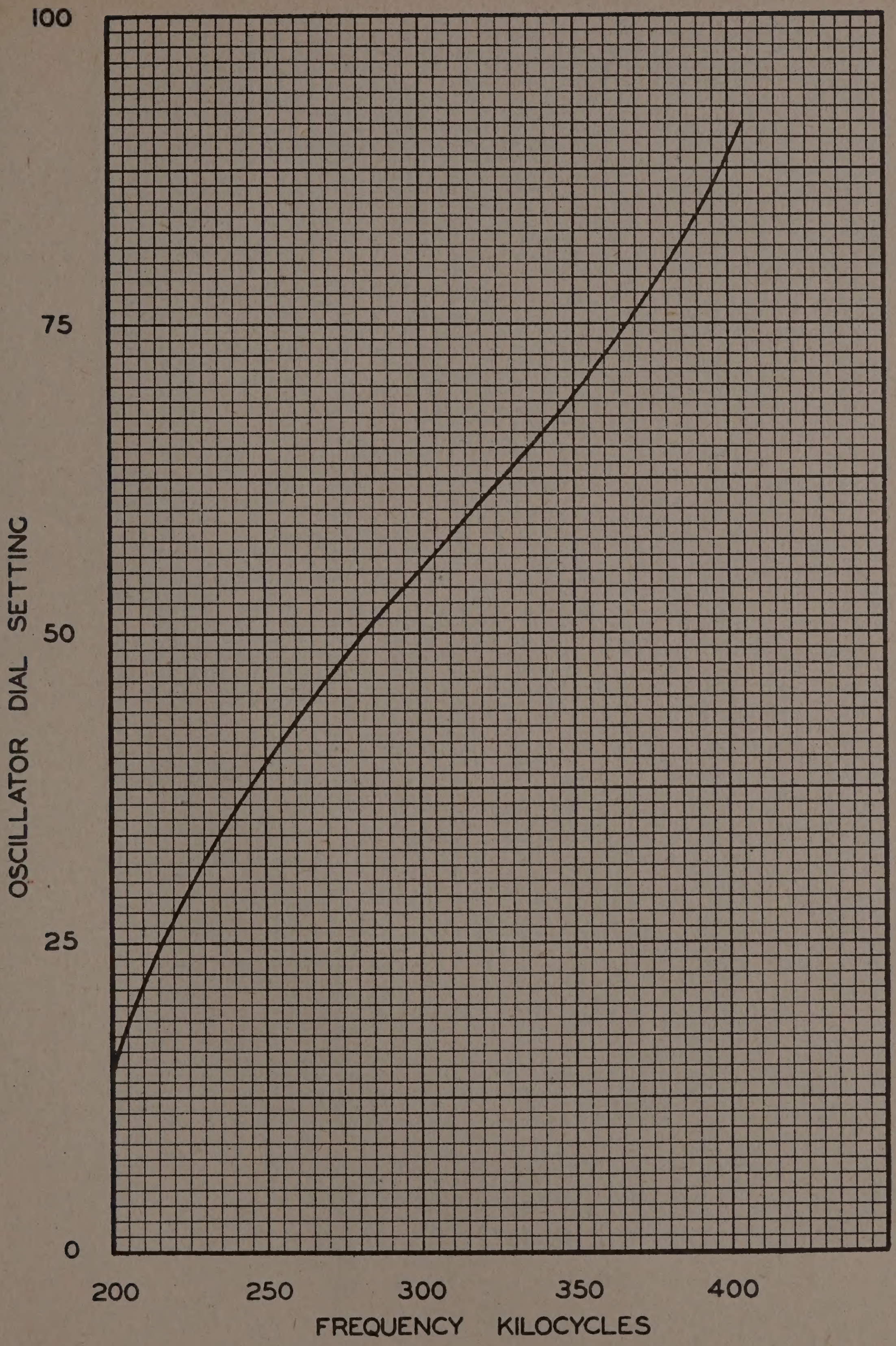


Fig. 23. OSC. PLATE Dial Calibration

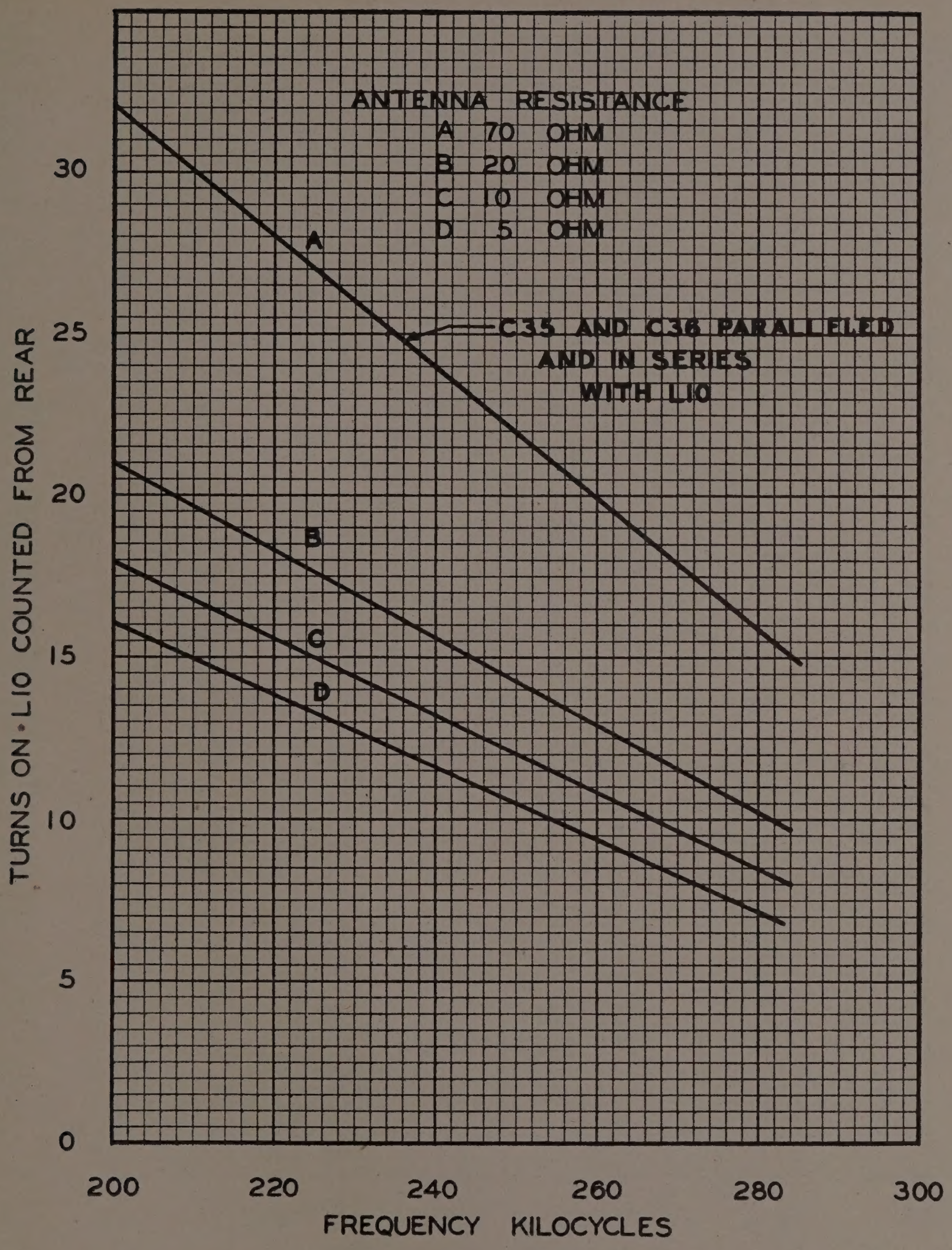


Fig. 24A. Radio-Frequency Transformer Coupling Turns 200 to 283 KC.

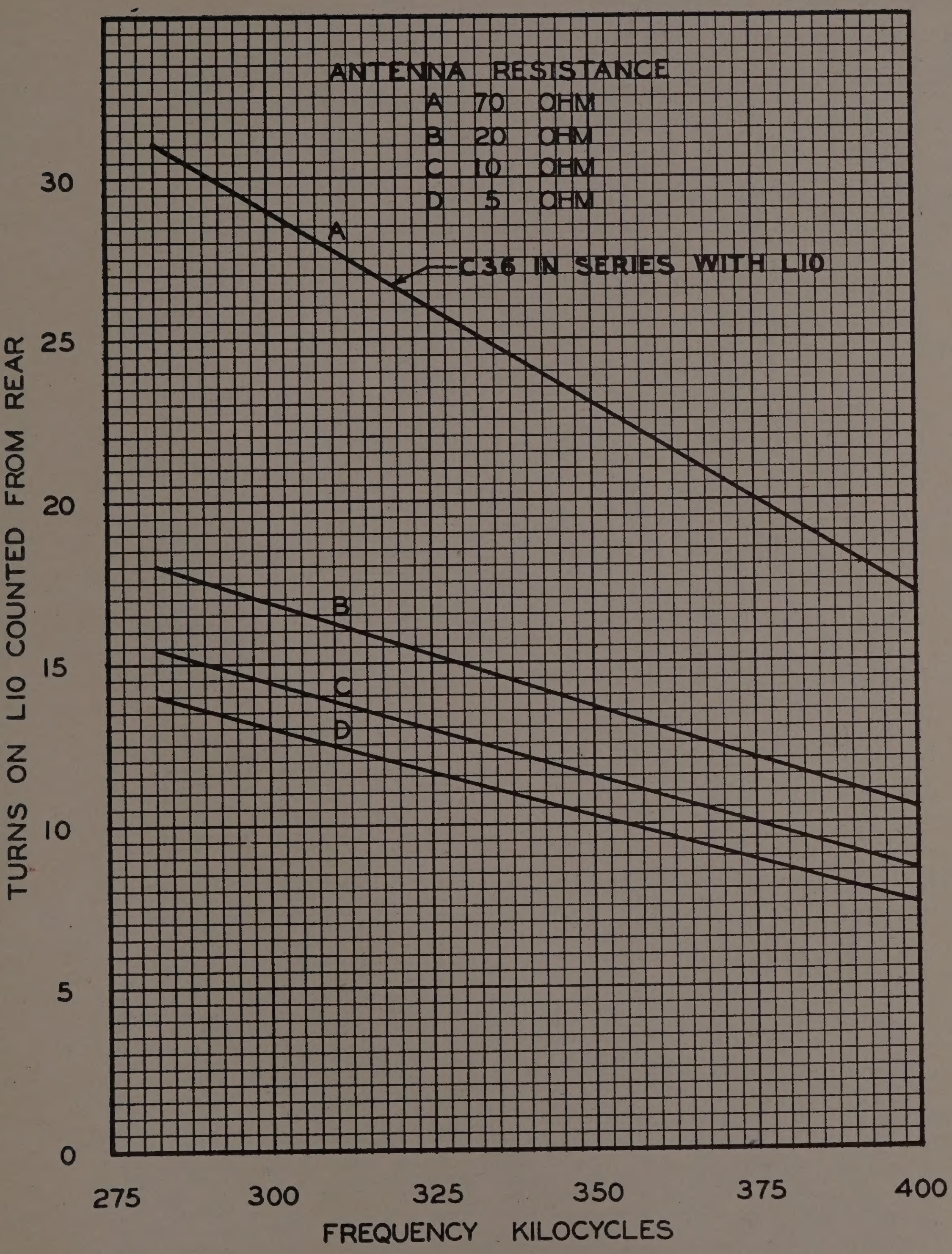


Fig. 24B. Radio-Frequency Transformer Coupling Turns 283 to 400 KC.

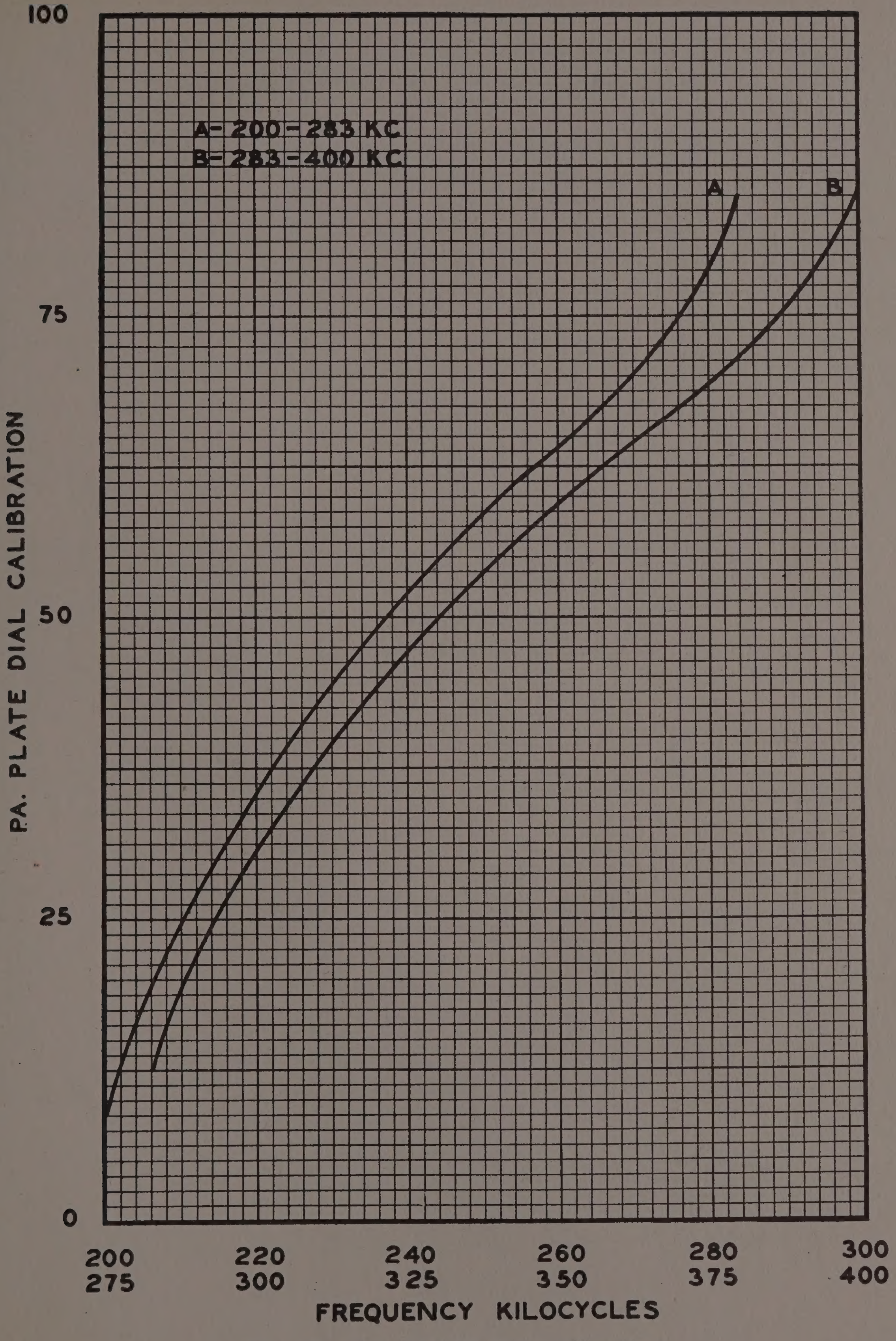


Fig. 25. PA. PLATE Dial Calibration

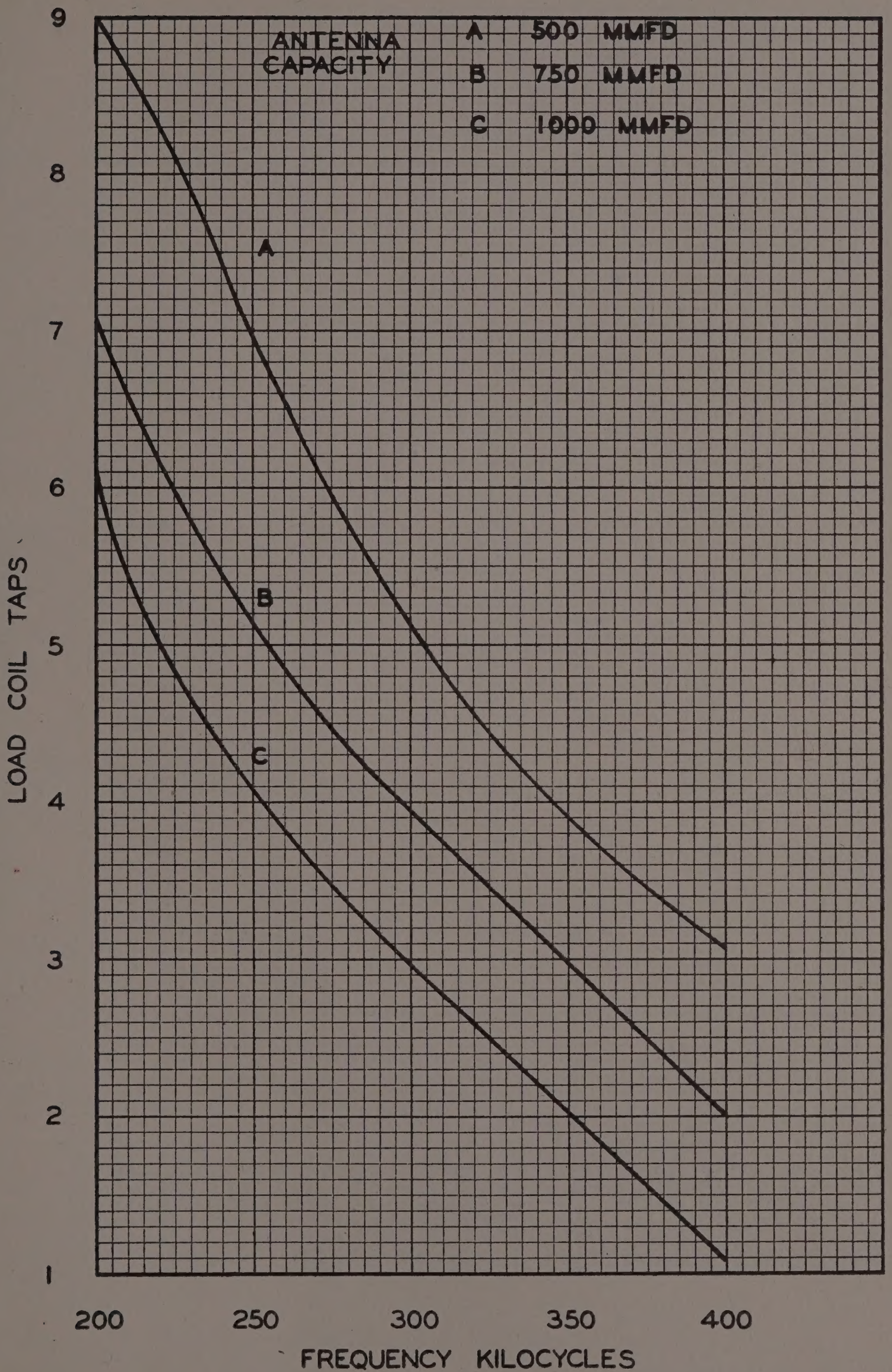


Fig. 26. Antenna Load Coil Taps

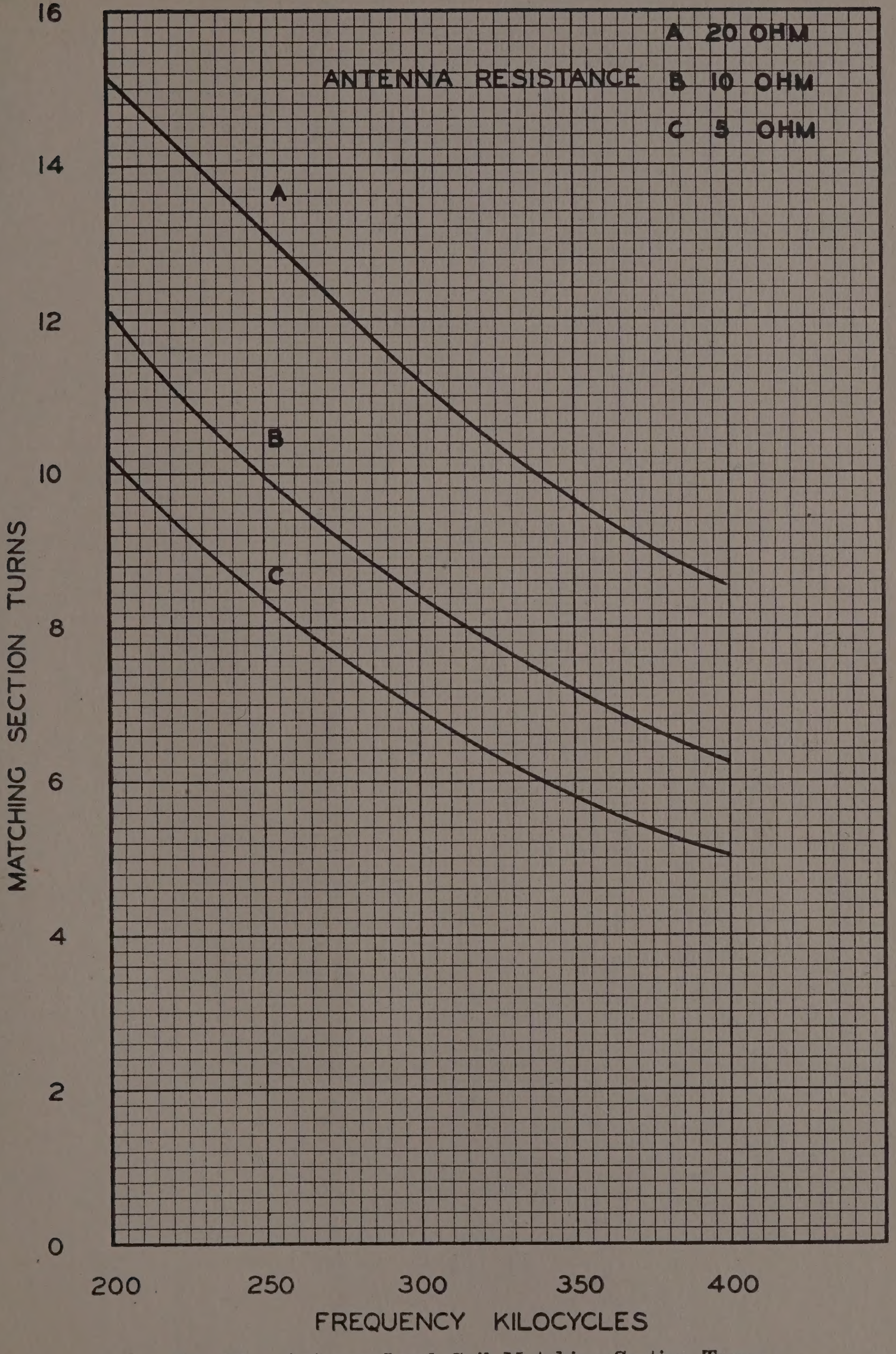
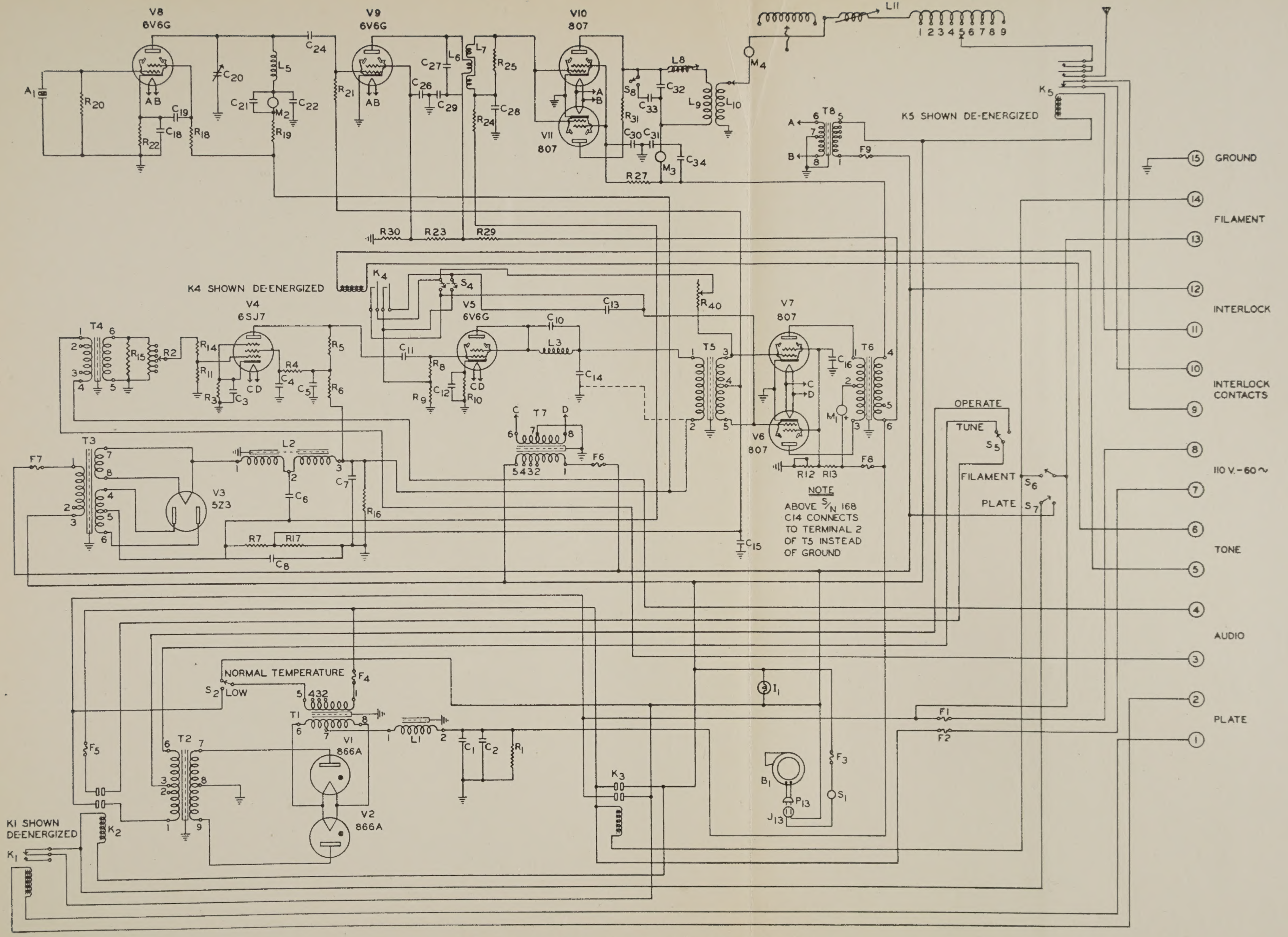
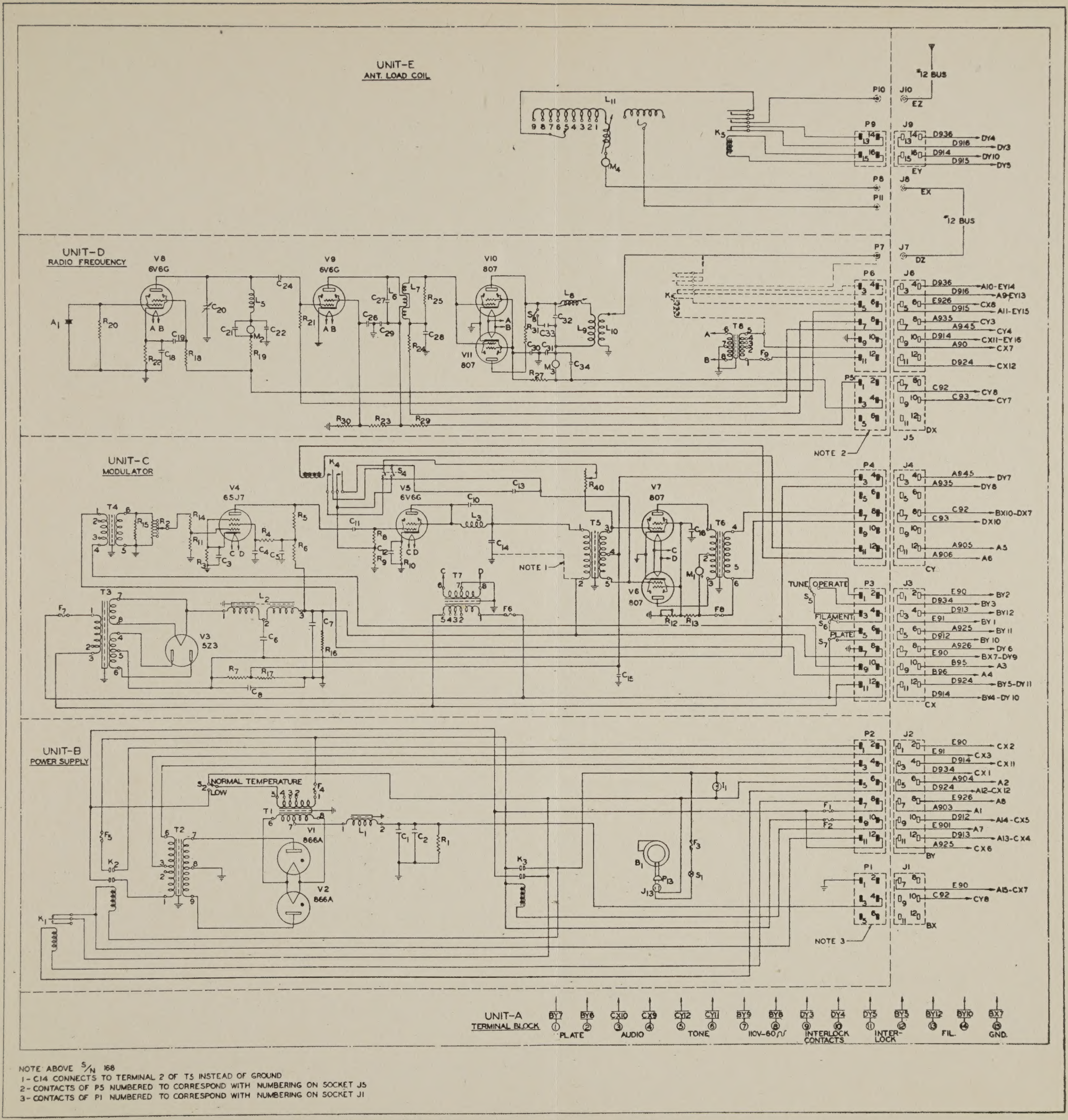


Fig. 27. Antenna Load Coil Matching Section Turns For 70 Ohm Line Connection at Remote Antenna Installations


V8
6V6G
V9
6V6G
V10
807
V11
807
L11
1 2 3 4 5 6 7 8 9
A1
R20
AB
C19
C18
R22
R18
C20
C21
L5
M2
C22
R19
C24
R21
C27
L6
L7
R25
C26
C29
C28
R24
S8
L8
C32
C33
R31
L9
L10
C30
C31
M3
C34
R27
M4
K5
K5 SHOWN DE-ENERGIZED
T8
A
B
F9
(15) GROUND
(14)
FILAMENT
(13)
(12)
INTERLOCK
(11)
(10)
INTERLOCK CONTACTS
(9)
(8)
110 V.-60 ~
(7)
(6)
TONE
(5)
(4)
AUDIO
(3)
(2)
PLATE
(1)
R30
R23
R29
K4 SHOWN DE-ENERGIZED
K4
S4
V4
6SJ7
V5
6V6G
C13
R40
V7
807
T4
R15
R2
R14
R11
R3
C3
R4
C4
C5
R5
R6
CD
C11
R8
R9
C12
R10
C10
L3
C14
T5
T6
C16
C
D
M1
V6
807
T3
F7
L2
V3
5Z3
C6
C7
R16
R7
R17
C8
T7
F6
F8
R12 R13
C15
OPERATE
TUNE
S5
FILAMENT
S6
PLATE
S7
NORMAL TEMPERATURE
F4
S2
LOW
T1
V1
866A
L1
C1
C2
R1
I1
F1
F2
F5
T2
K3
B1
P13
J13
F3
S1
V2
866A
K1 SHOWN DE-ENERGIZED
K2
K1

NOTE
ABOVE S/N 168
C14 CONNECTS
TO TERMINAL 2
OF T5 INSTEAD
OF GROUND

Fig. 28. TMO Transmitter—Complete Schematic


UNIT-E
ANT. LOAD COIL
L11
9 8 7 6 5 4 3 2 1
M4
K5
P10
J10
EZ
#12 BUS
P9
J9
D936
DY4
D916
DY3
D914
DY10
D915
DY5
EY
P8
J8
EX
P11
#12 BUS
UNIT-D
RADIO FREQUENCY
V8
6V6G
V9
6V6G
V10
807
V11
807
A1
R20
R22
C18
R18
C19
C20
C21
M2
C22
L5
R19
C24
R21
C26
C29
C27
L6
L7
R25
R24
C28
S8
R31
C33
C32
L8
L9
L10
C30
C31
M3
C34
R27
R30
R23
R29
T8
F9
P7
J7
DZ
P6
J6
A10-EY14
A9-EY13
E926
CX8
A11-EY15
A935
CY3
A945
CY4
CX11-EY16
A90
CX7
D924
CX12
P5
C92
CY8
C93
CY7
DX
J5
NOTE 2
UNIT-C
MODULATOR
V4
6SJ7
V5
6V6G
V7
807
V6
807
T4
R15
R2
R14
R11
R3
C3
R4
C4
C5
R5
R6
K4
S4
C11
R8
C12
R9
R10
C10
L3
C13
C14
R40
T5
T6
C16
M1
NOTE 1
T7
5 4 3 2
F6
F8
R12
R13
C15
T3
F7
V3
5Z3
L2
C6
C7
R16
R7
R17
C8
P4
J4
DY7
DY8
BX10-DX7
DX10
A905
A5
A906
A6
CY
TUNE
OPERATE
S5
FILAMENT
S6
PLATE
S7
P3
J3
E90
BY2
D934
BY3
D913
BY12
E91
BY1
A925
BY11
D912
BY10
A926
DY6
BX7-DY9
B95
A3
B96
A4
BY5-DY11
BY4-DY10
CX
UNIT-B
POWER SUPPLY
S2
NORMAL TEMPERATURE
LOW
F4
T1
V1
866A
V2
866A
L1
C1
C2
R1
T2
F5
K2
K1
K3
I1
F3
F1
F2
B1
P13
J13
S1
P2
J2
CX2
CX3
CX11
CX1
A904
A2
A12-CX12
A8
A903
A1
A14-CX5
E901
A7
A13-CX4
CX6
BY
P1
J1
A15-CX7
CY8
BX
NOTE 3
UNIT-A
TERMINAL BLOCK
BY7
BY6
CX10
CX9
CY12
CY11
BY9
BY8
DY3
DY4
DY5
BY5
BY12
BY10
BX7
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
⑭
⑮
PLATE
AUDIO
TONE
110V-60∿
INTERLOCK CONTACTS
INTER-LOCK
FIL.
GND.

NOTE ABOVE S/N 168
1- C14 CONNECTS TO TERMINAL 2 OF T5 INSTEAD OF GROUND
2- CONTACTS OF P5 NUMBERED TO CORRESPOND WITH NUMBERING ON SOCKET J5
3- CONTACTS OF P1 NUMBERED TO CORRESPOND WITH NUMBERING ON SOCKET J1

Fig. 29. TMO Transmitter—Wiring Schematic

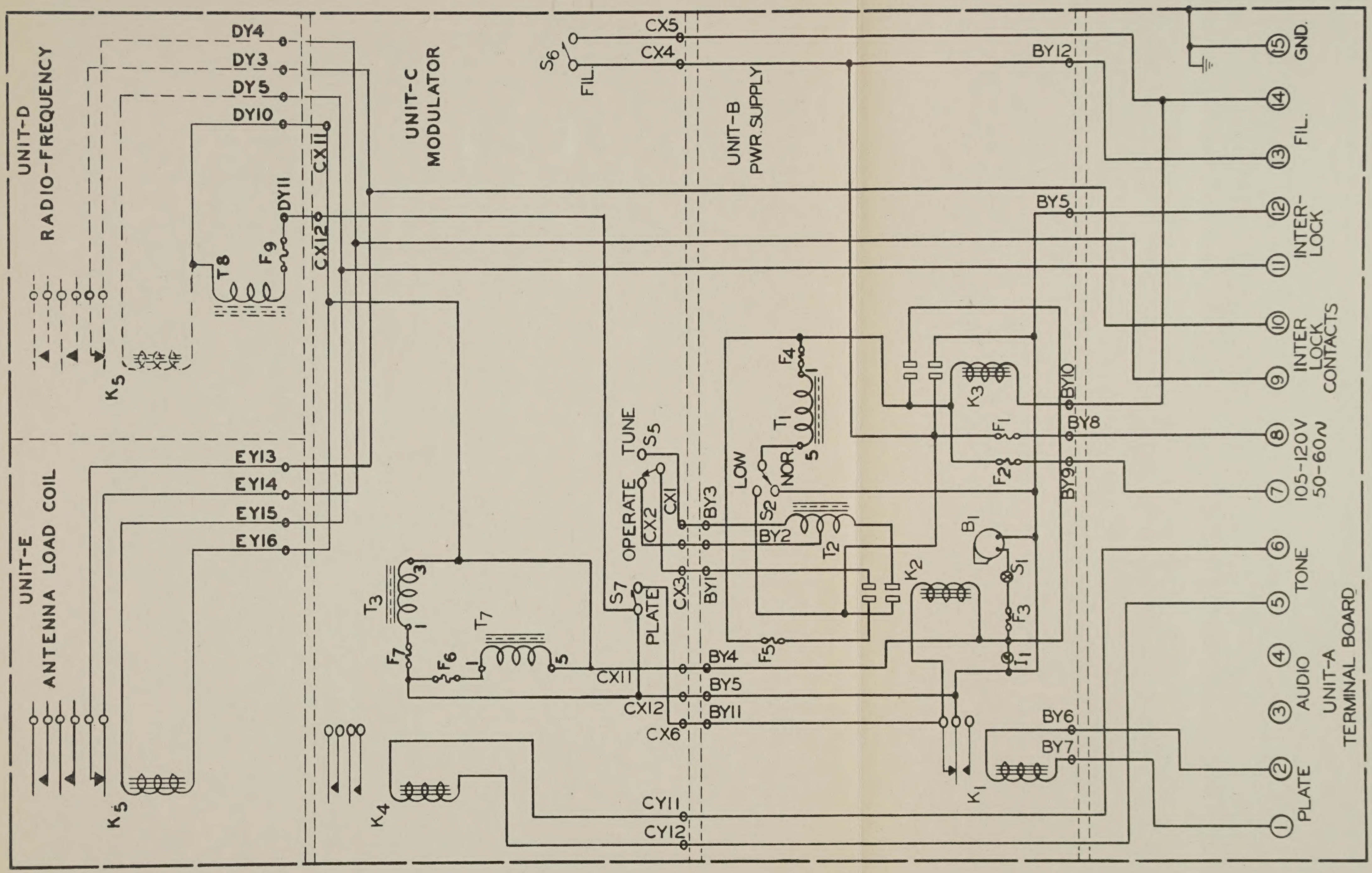
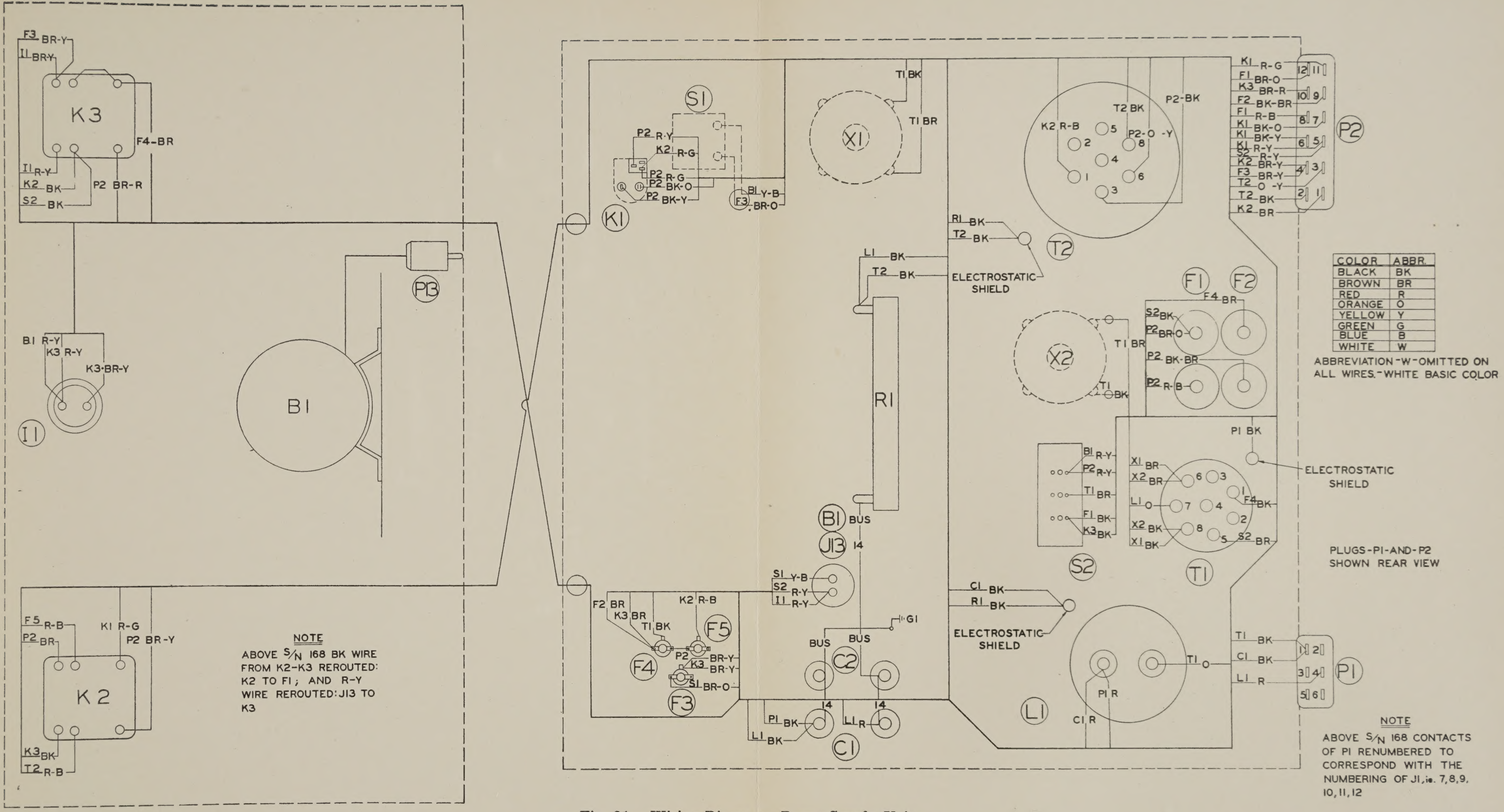

UNIT-D
RADIO-FREQUENCY
UNIT-E
ANTENNA LOAD COIL
UNIT-C
MODULATOR
UNIT-B
PWR. SUPPLY
UNIT-A
TERMINAL BOARD
DY4
DY3
DY5
DY10
DY11
CX11
CX12
T8
F9
K5
K5
EY13
EY14
EY15
EY16
T3
T7
F7
F6
1
3
1
5
K4
CY11
CY12
S7
PLATE
CX3
BY1
CX11
CX12
CX6
BY4
BY5
BY11
OPERATE
TUNE
S5
CX2
CX1
BY3
BY2
T2
K2
LOW
NOR.
S2
T1
1
5
F4
F5
B1
S1
F3
I1
K1
BY6
BY7
K3
F1
F2
BY8
BY9
BY10
BY5
BY12
CX5
CX4
S6
FIL.
⑮ GND.
⑭
⑬ FIL.
⑫
⑪ INTER-LOCK
⑩
⑨ INTER LOCK CONTACTS
⑧
⑦ 105-120V 50-60∿
⑥ TONE
⑤
④ AUDIO
③
②
① PLATE

Fig. 30. Schematic Diagram Control Circuit


K3
F3 BR-Y
I1 BR-Y
F4-BR
I1 R-Y
K2 BK
S2 BK
P2 BR-R
PB
B1 R-Y
K3 R-Y
K3-BR-Y
I1
B1
F5 R-B
P2 BR
K1 R-G
P2 BR-Y
K2
K3 BK
T2 R-B
S1
P2 R-Y
K2 R-G
P2 R-G
P2 BK-O
P2 BK-Y
B1 Y-B
F3 BR-O
K1
X1
T1 BK
T1 BR
T2 BK
P2-BK
K2 R-B
P2-O -Y
T2
R1 BK
T2 BK
ELECTROSTATIC SHIELD
L1 BK
T2 BK
R1
B1 BUS
J13 14
S1 Y-B
S2 R-Y
I1 R-Y
G1
F2 BR
K3 BR
T1 BK
K2 R-B
F5
F4
P2 BR-Y
K3 BR-Y
S1 BR-O
F3
BUS
C2
C1
P1 BK
L1 BK
L1 R
F1
F2
F4 BR
S2 BK
P2 BR-O
P2 BK-BR
P2 R-B
X2
T1 BR
T1 BK
P1 BK
B1 R-Y
P2 R-Y
T1 BR
F1 BK
K3 BK
X1 BR
X2 BR
L1 O
X2 BK
X1 BK
F4 BK
S2 BR
S2
T1
C1 BK
R1 BK
L1
P1 R
C1 R
T1 O
T1 BK
C1 BK
L1 R
P1
K1 R-G
F1 BR-O
K3 BR-R
F2 BK-BR
F1 R-B
K1 BK-O
K1 BK-Y
K1 R-Y
S2 R-Y
K2 BR-Y
F3 BR-Y
T2 O-Y
T2 BK
K2 BR
P2
PLUGS-P1-AND-P2 SHOWN REAR VIEW

COLOR	ABBR.
BLACK	BK
BROWN	BR
RED	R
ORANGE	O
YELLOW	Y
GREEN	G
BLUE	B
WHITE	W

ABBREVIATION-W-OMITTED ON ALL WIRES.-WHITE BASIC COLOR

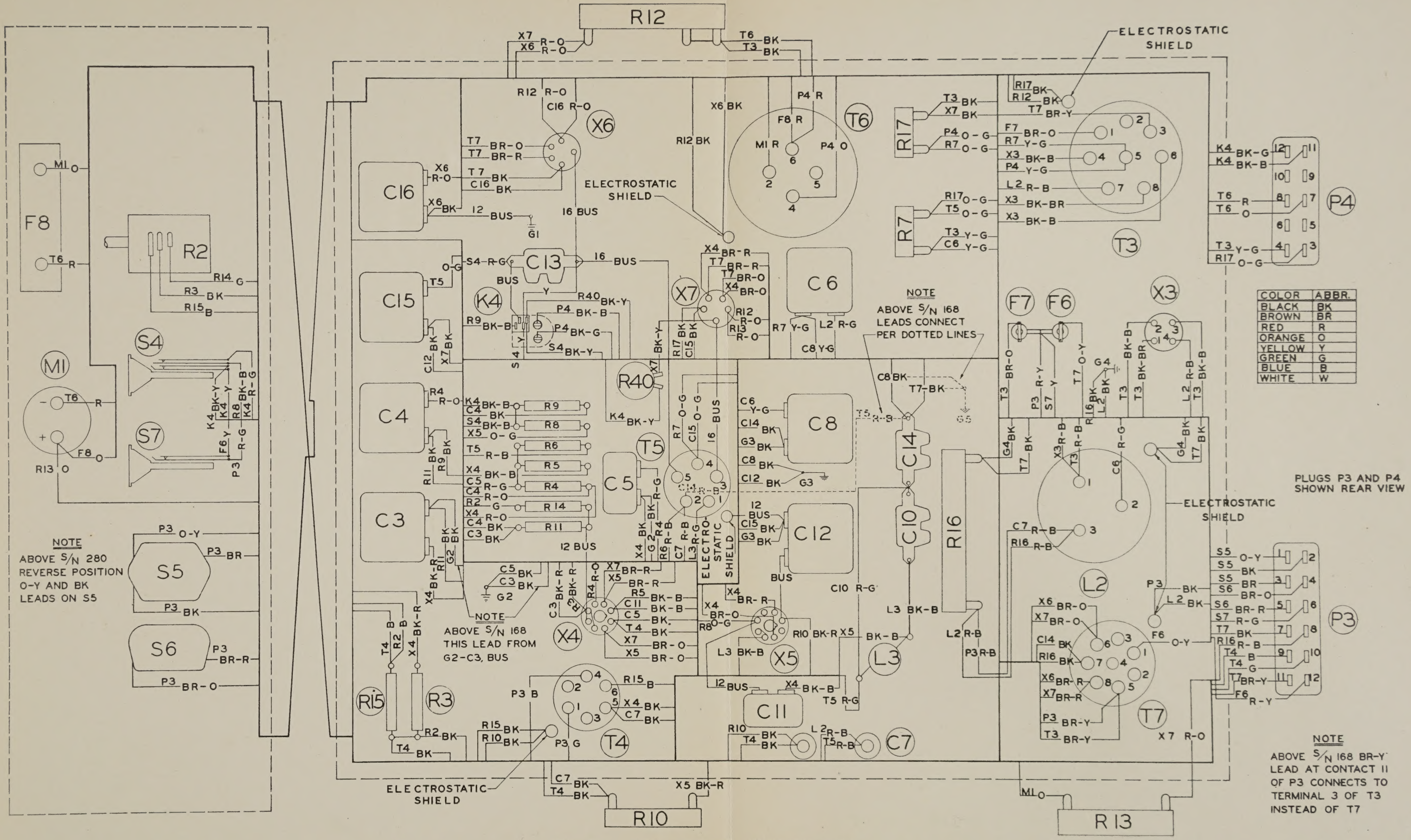
NOTE

ABOVE S/N 168 BK WIRE FROM K2-K3 REROUTED: K2 TO F1; AND R-Y WIRE REROUTED: J13 TO K3

NOTE

ABOVE S/N 168 CONTACTS OF P1 RENUMBERED TO CORRESPOND WITH THE NUMBERING OF J1, ie. 7, 8, 9, 10, 11, 12

Fig. 31. Wiring Diagram—Power-Supply Unit



R12
ELECTROSTATIC SHIELD
F8
R2
M1
S4
S7
S5
S6
C16
C15
C4
C3
K4
X6
C13
X7
T6
R17
R7
T3
P4
C6
F7
F6
X3
R40
T5
C5
C8
C14
C10
R16
C12
L2
X4
X5
L3
T7
P3
R15
R3
T4
C11
C7
R10
R13
12 BUS
16 BUS
PLUGS P3 AND P4 SHOWN REAR VIEW

NOTE
ABOVE S/N 280 REVERSE POSITION O-Y AND BK LEADS ON S5

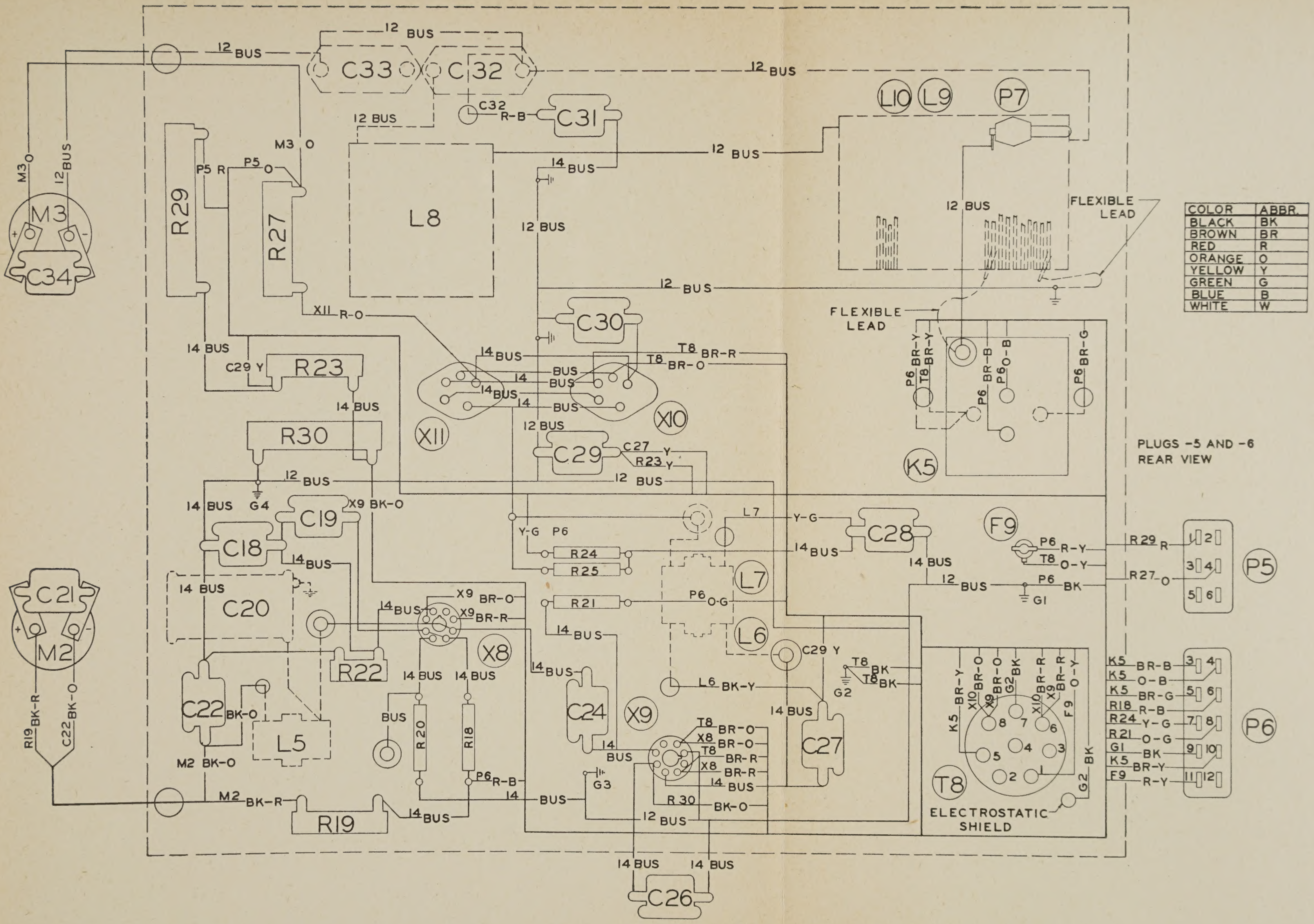
NOTE
ABOVE S/N 168 THIS LEAD FROM G2-C3, BUS

NOTE
ABOVE S/N 168 LEADS CONNECT PER DOTTED LINES

NOTE
ABOVE S/N 168 BR-Y LEAD AT CONTACT 11 OF P3 CONNECTS TO TERMINAL 3 OF T3 INSTEAD OF T7

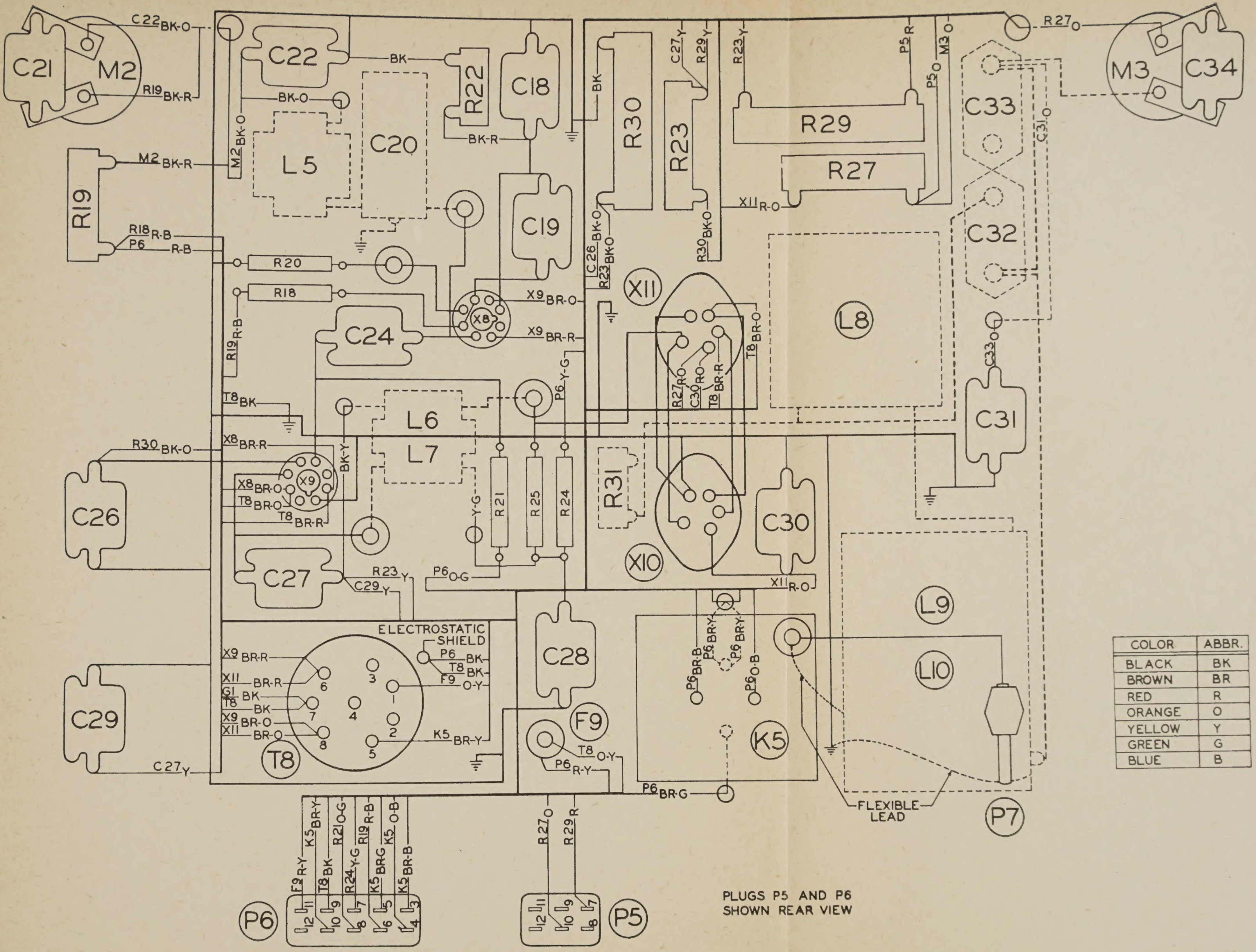
COLOR	ABBR.
BLACK	BK
BROWN	BR
RED	R
ORANGE	O
YELLOW	Y
GREEN	G
BLUE	B
WHITE	W

Fig. 32. Wiring Diagram—Modulator Unit


C33
C32
C31
C30
C29
C28
C27
C26
C24
C22
C21
C20
C19
C18
C34
M3
M2
L8
L5
L6
L7
L9
L10
P7
R29
R27
R23
R30
R22
R19
R20
R18
R24
R25
R21
X11
X10
X9
X8
K5
F9
T8
P5
P6
G1
G2
G3
G4
12 BUS
14 BUS
FLEXIBLE LEAD
ELECTROSTATIC SHIELD
PLUGS -5 AND -6 REAR VIEW

COLOR	ABBR.
BLACK	BK
BROWN	BR
RED	R
ORANGE	O
YELLOW	Y
GREEN	G
BLUE	B
WHITE	W

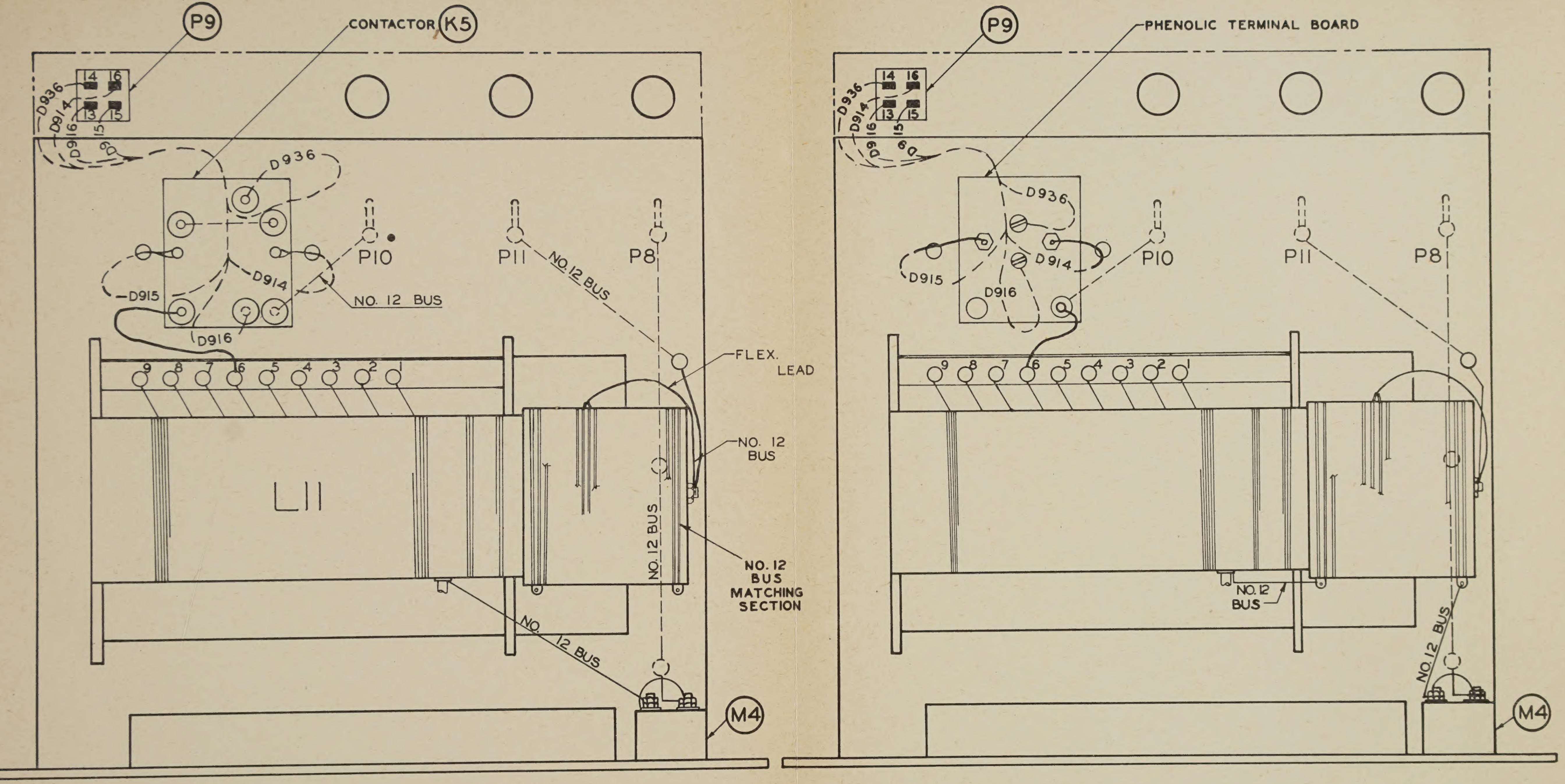
Fig. 33A. Wiring Diagram—Radio-Frequency Unit. S/N below 169


C21
M2
C22 BK-O
R19 BK-R
C22
BK
R22
C18
BK-O
BK-R
C20
L5
M2 BK-O
M2 BK-R
R19
R18 R-B
P6 R-B
R20
R18
C19
X9 BR-O
X8
X9 BR-R
C24
R19 R-B
T8 BK
L6
L7
P6 Y-G
R30 BK-O
X8 BR-R
X9
BK-Y
X8 BR-O
T8 BR-O
T8 BR-R
C26
Y-G
R21
R25
R24
C27
R23 Y
C29 Y
P6 O-G
ELECTROSTATIC SHIELD
X9 BR-R
X11 BR-R
G1 BK
T8 BK
X9 BR-O
X11 BR-O
P6 BK
T8 BK
F9 O-Y
K5 BR-Y
T8
C29
C27 Y
C28
F9
T8 O-Y
P6 R-Y
P6 BR-G
BK
R30
C27 Y
R29 Y
R23
R23 Y
R29
P5 R
M3 O
P5 O
R27
R27 O
X11 R-O
R30 BK-O
C26 BK-O
R23 BK-O
X11
T8 BR-O
R27 R-O
C30 R-O
T8 BR-R
L8
C33
C32
C31 O
M3
C34
C33 O
C31
R31
X10
C30
X11 R-O
P6 BR-B
P6 BR-Y
P6 BR-Y
P6 O-B
K5
L9
L10
FLEXIBLE LEAD
P7
F9 R-Y
K5 BR-Y
T8 BK
R21 O-G
R24 Y-G
R19 R-B
K5 BR-G
K5 O-B
K5 BR-B
P6
12 11 10 9 8 7 6 5 4 3
R27 O
R29 R
12 11 10 9 8 7
P5

COLOR	ABBR.
BLACK	BK
BROWN	BR
RED	R
ORANGE	O
YELLOW	Y
GREEN	G
BLUE	B

PLUGS P5 AND P6 SHOWN REAR VIEW

Fig. 33B. Wiring Diagram—Radio-Frequency Unit. S/N above 168


P9
CONTACTOR K5
14
16
13
15
D936
D914
D916
D9
D915
NO. 12 BUS
P10
P11
P8
NO. 12 BUS
FLEX. LEAD
NO. 12 BUS
9
8
7
6
5
4
3
2
1
L11
NO. 12 BUS
NO. 12 BUS MATCHING SECTION
NO. 12 BUS
M4
P9
PHENOLIC TERMINAL BOARD
14
16
13
15
D936
D914
D916
D9
D936
D914
D915
D916
P10
P11
P8
9
8
7
6
5
4
3
2
1
NO. 12 BUS
NO. 12 BUS
M4

AS USED LOCALLY IN TMO CABINET

AS USED REMOTELY IN LOAD COIL HOUSING

Fig. 34. Wiring Diagram—Antenna Load Coil Unit

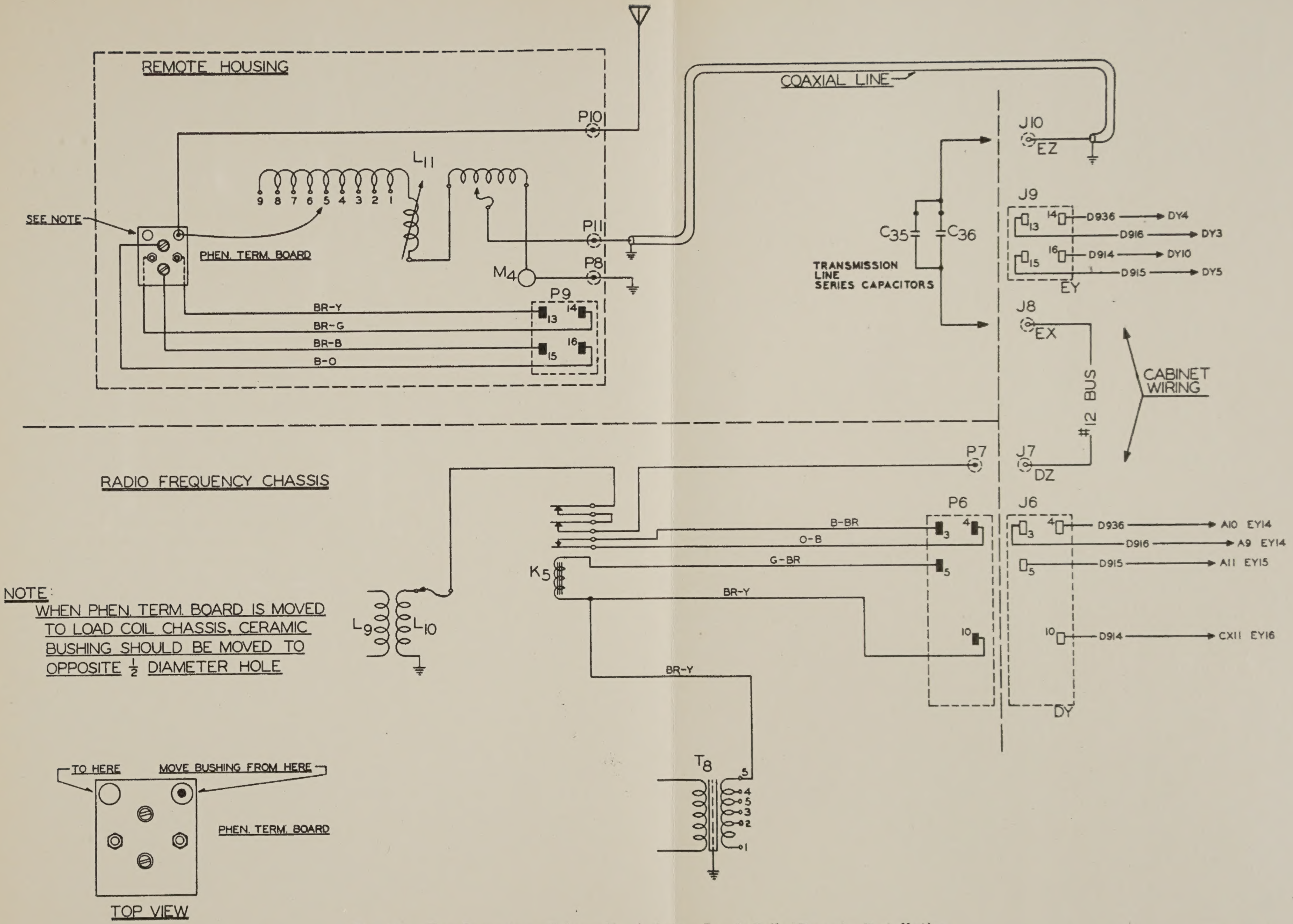

REMOTE HOUSING
COAXIAL LINE
P10
L11
9 8 7 6 5 4 3 2 1
SEE NOTE
PHEN. TERM. BOARD
P11
M4
P8
P9
13 14
15 16
BR-Y
BR-G
BR-B
B-O
J10
EZ
J9
14 D936 DY4
13 D916 DY3
16 D914 DY10
15 D915 DY5
EY
C35
C36
TRANSMISSION LINE SERIES CAPACITORS
J8
EX
#12 BUS
CABINET WIRING
P7
J7
DZ
RADIO FREQUENCY CHASSIS
P6
J6
B-BR
O-B
G-BR
BR-Y
3 4
5
10
4 D936 A10 EY14
3 D916 A9 EY14
5 D915 A11 EY15
10 D914 CX11 EY16
DY
K5
L9
L10
NOTE:
WHEN PHEN. TERM. BOARD IS MOVED TO LOAD COIL CHASSIS, CERAMIC BUSHING SHOULD BE MOVED TO OPPOSITE 1/2 DIAMETER HOLE
T8
5 4 5 3 2 1
TO HERE
MOVE BUSHING FROM HERE
PHEN. TERM. BOARD
TOP VIEW

Fig. 35. Supplementary Schematic Antenna Load Coil—Remote Installation

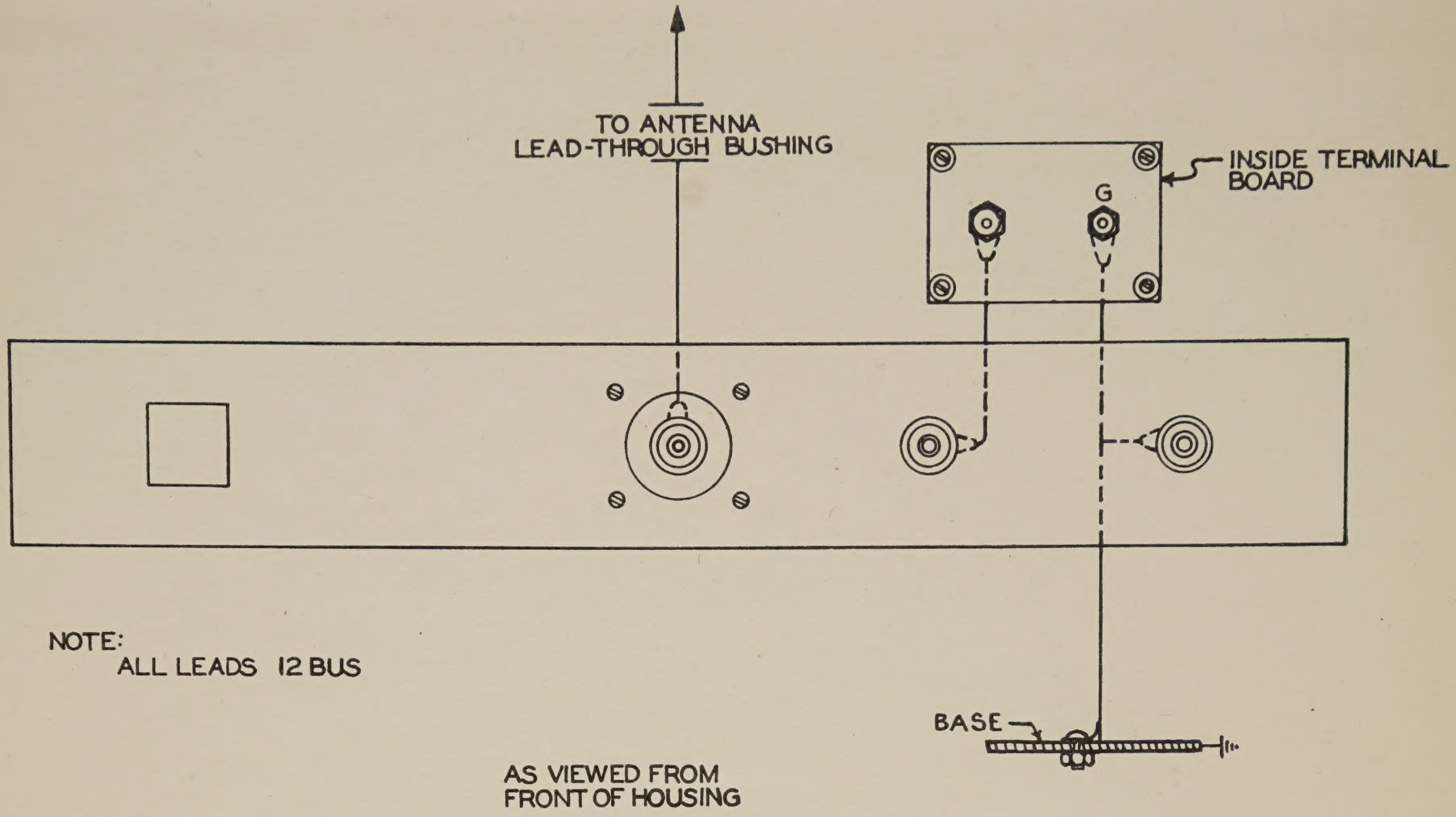

TO ANTENNA
LEAD-THROUGH BUSHING
G
INSIDE TERMINAL BOARD
NOTE:
ALL LEADS 12 BUS
BASE
AS VIEWED FROM FRONT OF HOUSING

Fig. 36. Wiring Diagram—Load Coil Housing

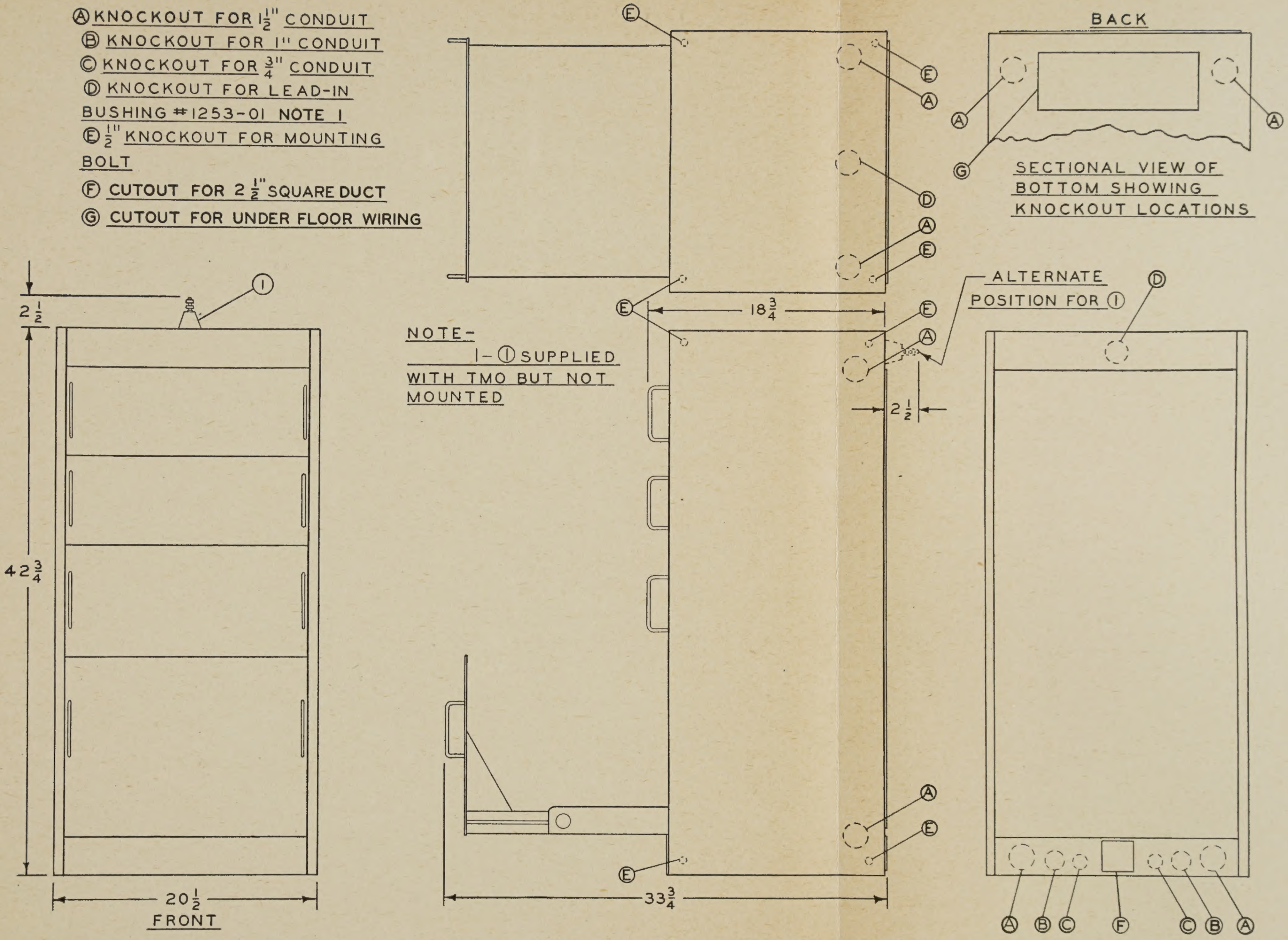

Ⓐ KNOCKOUT FOR 1½" CONDUIT
Ⓑ KNOCKOUT FOR 1" CONDUIT
Ⓒ KNOCKOUT FOR ¾" CONDUIT
Ⓓ KNOCKOUT FOR LEAD-IN BUSHING #1253-01 NOTE 1
Ⓔ ½" KNOCKOUT FOR MOUNTING BOLT
Ⓕ CUTOUT FOR 2½" SQUARE DUCT
Ⓖ CUTOUT FOR UNDER FLOOR WIRING
BACK
SECTIONAL VIEW OF BOTTOM SHOWING KNOCKOUT LOCATIONS
ALTERNATE POSITION FOR ①
NOTE-
1-① SUPPLIED WITH TMO BUT NOT MOUNTED
2½
42¾
20½
FRONT
18¾
2½
33¾
①
Ⓐ
Ⓑ
Ⓒ
Ⓓ
Ⓔ
Ⓕ
Ⓖ

Fig. 37. Outline Drawing